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THE BEECH-BIRCH-MAPLE Forest Type in Pennsylvania

By

Joseph S. Illick
and
LeRoy Frontz

BULLETIN 46

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS

Charles E. Dorworth, *Secretary*
Joseph S. Illick, *State Forester*

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INTENTIONAL SECOND EXPOSURE

Overlooking Extensive Areas of Young Beech-Birch-Maple Forests in Northern Pennsylvania

INTRODUCTION

WHEN lumbermen began operations, about 1860, in the mountainous sections of north-central Pennsylvania, they found valleys, hillsides, and mountains covered with a dense growth of enormous white pine and hemlock, among which were splendid specimens of hardwoods. Early logging in these forests first took the white pine and later the hemlock. Little hardwood timber was removed except in clearing for settlement; but as time went on and the demand for lumber developed, cutting was extended to include the more valuable hardwoods. Even the poorest of these species are now so valuable for certain purposes that stands are usually cut clean; and even tops, branches, and other small-sized materials are utilized.

With the culling of the softwoods from the great northern forests of Pennsylvania, the area occupied by the now dominant beech-birch-maple type has been extended until it covers about one-third of the total forest area. It is one of the most important types found in the State. The species growing in these forests are extensive and intensive reproducers; hence, in the future we may expect the more aggressive, faster-growing trees gradually to crowd out and reduce the number of the less aggressive, and, in the main, poorer and less desirable trees. Because of the very nature of these forests it is doubtful whether present conditions will change to any appreciable degree, except for this gradual and natural improvement, and to such extent as the forest may be influenced by cutting and fire.

Although the demand for products of this type of forest has been increasing from year to year, merchantable stands of such timber have almost disappeared. Where the beech-birch-maple forests of marketable size have become exhausted, the industries depending upon them for raw material have in most instances moved to other states, or have ceased to operate. This has resulted in impoverished forest communities. For this reason, and because of the variety of useful woods and other products obtained from this type of forest, it became imperative that a body of reliable information concerning such forests be secured. Therefore, a study of the growth, yield, and other silvical characteristics was made by the Pennsylvania Department of Forests and Waters. It is hoped that the results of this study and the conclusions set forth in this bulletin will be of considerable value to forest owners in Pennsylvania, and will open a gateway to a profitable enterprise by encouraging the proper handling of this very interesting and useful forest type.

Overlooking Extensive Areas of Young Beech-Birch-Maple Forests in Northern Pennsylvania

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Fig. 1. A Beautiful Beech-Birch-Maple Forest Bordering the Historic "Coudersport-Jersey Shore Pike" in Potter County, Pennsylvania

The Beech-Birch-Maple Forest Type in Pennsylvania

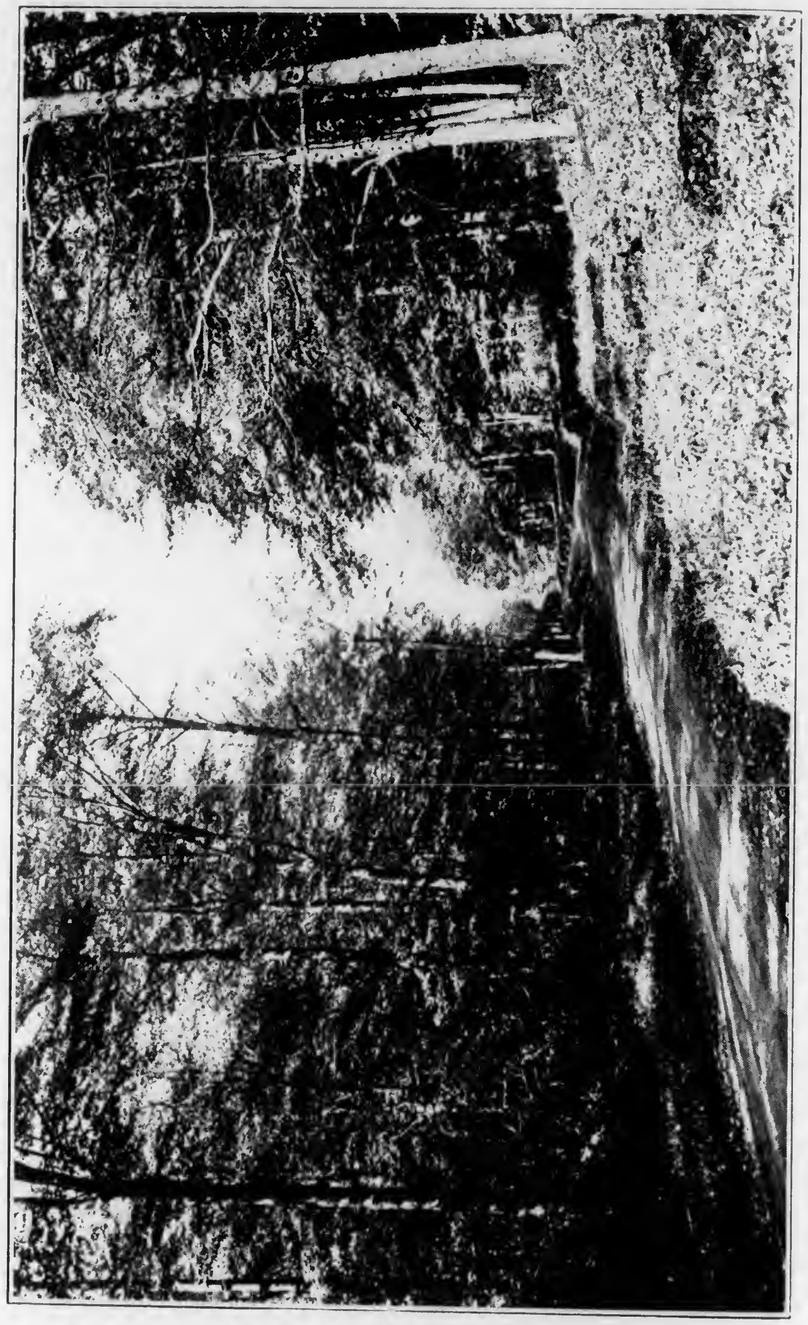
DESCRIPTION OF THE BEECH-BIRCH-MAPLE FOREST TYPE

The beech-birch-maple type takes its name from the fact that beech, birch, and maple trees are its chief components. Sometimes this kind of forest is described under the name of "the northern hardwood forest." Although this type possesses a general uniformity of character sufficient to distinguish it from other important forest types, its composition varies considerably throughout its range.

The more characteristic species of the type are beech (Fagus grandifolia, Ehrhart), yellow birch (Betula lutea, Michx.), black birch (Betula lenta, Linnæus), and sugar maple (Acer saccharum, Marsh). Associated with these principal species of this type are such important trees as wild black cherry (Prunus serotina, Ehrhart), white ash (Fraxinus americana, Linnæus), and some inferior trees such as fire cherry (Prunus pennsylvanica, Linnæus), blue beech (Carpinus caroliniana, Walter), and ironwood (Ostrya virginiana (Miller) K. Koch). These inferior and temporary tree species usually occur in greater or lesser numbers throughout the entire range of the type. Fire cherry ordinarily is one of the first trees to establish itself on burned-over areas in this type of forest. Often it is present in large numbers following lumbering. The fire cherry, blue beech, and ironwood are short-lived trees. They act as a nurse crop, among and under which the commercially valuable and important hardwoods establish themselves.

Although this somewhat variable condition of composition exists, it is obvious that to consider beech, birch, and maple stands or wild black cherry, white ash, and basswood stands as separate types, as well as the temporary fire cherry stands, would lead to an almost impossible task when all of these trees grow together in various degrees of mixture. Such a division would require refinements in this study which would add little, if anything, to its value; hence no attempt at minute distinctions has been made.

Stands of white ash, wild black cherry, and basswood, with scattered specimens of maple and beech are common in the northwestern section of the State, west of the Allegheny River valley. The land there being better suited for agricultural purposes, probably less than 40 per cent



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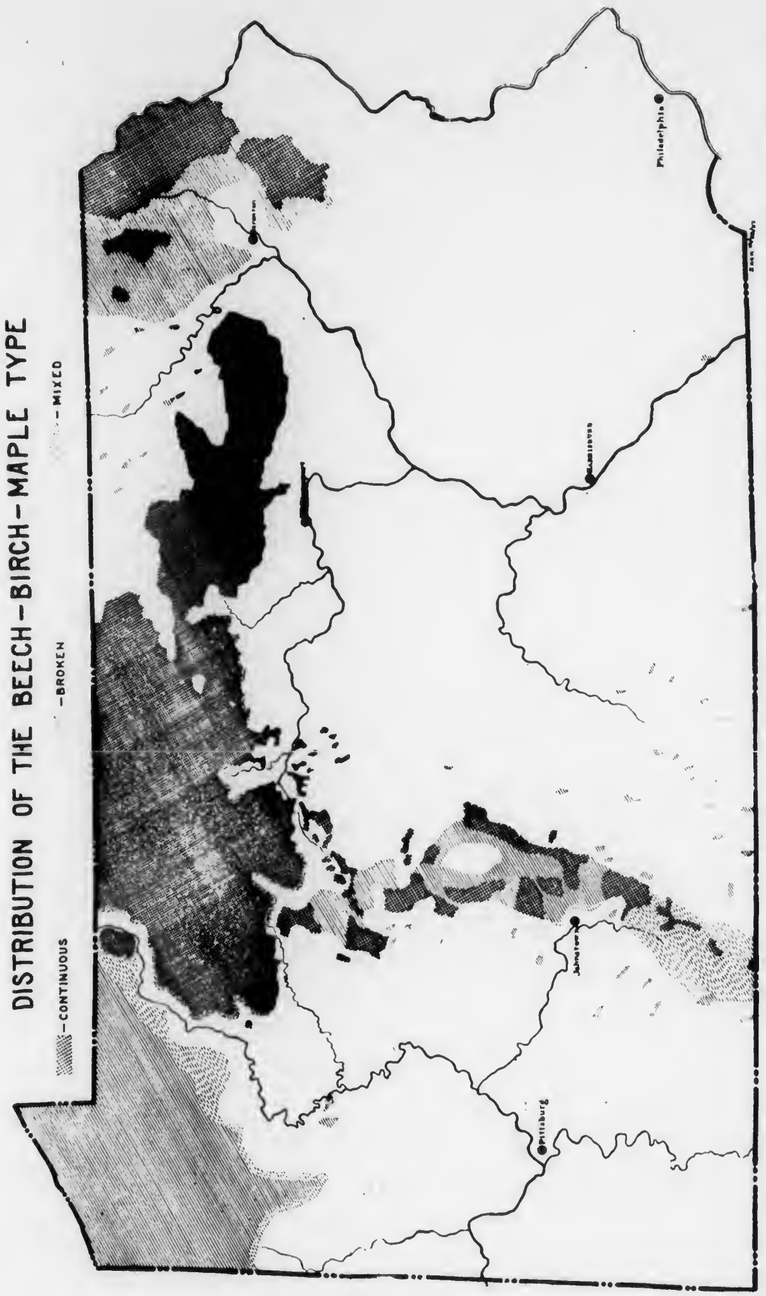

Fig. 2. In North-Central and Locally in Northeastern Pennsylvania Occur Continuous (Unbroken) Stands of Beech, Birch, and Maple. In the Northwestern and Over Large Areas in the Northeastern Part These Trees Occur in Broken Stands; While Along the Alleghenies, Particularly in Somerset and Adjoining Counties, They Occur in Mixture With Other Trees, Chiefly Oaks.

of the area is devoted to growing trees. Existing stands cover limited areas, and belong chiefly in the farm woodlot class.

The term "transition zone" is used to describe the wooded region between two distinct and typical forest types. In the transition zone, trees characteristic of both the adjoining types of forest usually occur in mixture. In some instances this zone is rather narrow, and comparatively wide in others, its width being determined largely by topography and partly by the direction of the mountain ridges.

In the eastern transition zone and in parts of the southern zone between hardwood types, red maple is often found in abundance. In certain sections this tree forms almost pure stands. As is the case in the northwestern section of the State, a considerable proportion of the northeastern land area also is used for agricultural purposes.

Much of the southern transition zone is cut by the larger stream valleys. In these sections a marked intermingling of types occurs, which is especially noticeable in the vicinity of Emporium, Cameron County, where the beech-birch-maple type is found on the northern faces of the hills and in the deep cool ravines; while on the warm southern faces of the hills and ridge tops the oak-chestnut type predominates.

The white oak is found to be the most important indicator-tree of the oak-chestnut forest growth of northern Pennsylvania. Wherever this tree occurs in considerable numbers in Pennsylvania, other oaks, chestnut, and additional hardwoods, typically southern in range, are also found. Such stands are assigned to the oak-chestnut growth, while those containing few or no specimens of white oak usually are classified within the beech-birch-maple type.

WHERE THE BEECH-BIRCH-MAPLE TYPE OCCURS IN PENNSYLVANIA

The beech-birch-maple type of forest is distinctly northern, and is very important in the Lake States, the Adirondacks, and in New England. The most southerly typical and extensive beech-birch-maple forests are found on the highlands of northern Pennsylvania.

In Pennsylvania the beech-birch-maple type reaches its best development on the fresh well-drained fertile soils of the north-central section, at elevations ranging from 1,000 to 2,500 feet. Owing to the range in elevation, the variation in soils, and other growth factors, as well as the intermingling of the oak-chestnut with the beech-birch-maple in the transition zones, it is difficult to fix definite geographic boundaries for the latter type.

In north-central Pennsylvania, where this type of forest now appears almost to the exclusion of other forest types, it occupies the highlands, extending in a practically unbroken stand westward and eastward

beyond the boundaries of the State. Where the Susquehanna and the Allegheny River valleys break through this region, and also in the valleys of their main tributary streams, the oak-chestnut type often appears in abudance.

From the north-central section of the State, beech, birch, and maple follow the mountains in a southwesterly direction to and beyond the State's southern boundary. In this southern part of its range in Pennsylvania, the type occurs in more or less detached bodies at higher elevations, along streams, and in cool valleys. Trees characteristic of the beech-birch-maple type and of the oak-chestnut growth are here found growing side by side in mixture. The mountain tops, some of which rise to the highest elevations in the State, are covered by a growth of oak-chestnut frequently interspersed with pitch pine, except in northern Somerset County, where the true beech-birch-maple type is found. The mixed condition in southern Somerset County is especially noticeable because of the large sugar maple trees in the farm woodlots and the "sugar bushes." Large specimens of white, rock, red, other oaks, and chestnut are often present, and this same mixed condition appears to a greater or lesser degree in the southern ranges, west of the Allegheny River valley.

Isolated stands of beech-birch-maple sometimes occur in scattered sections of the State. One of the most notable examples, a widely detached outpost, is found in a deep cool narrow valley in the Mont Alto State Forest, near Waynesboro, in Franklin County.

The chief climatic factors determining the distribution of forest types are temperature and moisture. The region occupied by beech-birch-maple is distinctly humid, with normal annual precipitation ranging from 40 to 50 inches.* The temperature, in turn influenced by elevation, is the principal determining factor of composition and distribution. Where this type of forest is found in Pennsylvania, the annual mean temperature ranges from 44 to 49 degrees.* Killing frosts may occur there after May 10 and before September 30.* The growing season is approximately four and one-half to five months in length.

Soils in the beech-birch-maple region of Pennsylvania are residual and glacial in origin. The residual soils are for the most part deep, fresh, and fertile, of a sand or sand loam texture. They were derived largely from sandstone and conglomerate rock formations. The fresh well-drained soils of Potter County afford beech-birch-maple ideal conditions for growth, and here this type of forest reaches its optimum development. Most of these soils may be classed as Site Quality 1 for tree growth.

The glacial soils range from deep fertile agricultural land with few boulders, to the bouldery deposits on the bedrock of the mountain tops

* Soils of Pennsylvania. Bulletin No. 257, State Department of Agriculture.

and steep slopes. These areas are often almost entirely covered with angular rock fragments. In some sections, especially in the northeastern part of the State, an abundance of loose rocks and boulders occurs. However, as the greater part of the glacial region in Pennsylvania lies at the southern extent of the terminal moraine, these regions were not glaciated to the same severe extent as were the regions located further to the north. These soils, as well as those of residual formation, are comparatively deep and fertile. There is a distinct tendency toward sand rather than clay loam. With the exception of some few of the larger stream valleys, practically all of the area wherein extensive beech-birch-maple forests occur is naturally forest land, because of the steep slopes, the high elevations, and the comparatively short growing season, or a combination of these factors.

EXTENT OF BEECH-BIRCH-MAPLE FORESTS IN PENNSYLVANIA

A conservative estimate shows that we have more than 4,500,000 acres of young beech-birch-maple forest in Pennsylvania; that is, forest land potentially best suited for growing the kind of trees characteristic of this forest type. More than 205,000 acres or better than 16 per cent of the 1,285,170 acres (August 1, 1928) of the State forest land is located within the region occupied by the beech-birch-maple type.

Approximately one-third of the total forest area of Pennsylvania is included within this forest region; hence the important part that the beech-birch-maple forests are destined to play in future lumbering and forestry in Pennsylvania is apparent.

The extensive and valuable virgin forest growth which once covered this State has almost disappeared. Today there remain in all of Pennsylvania only 20,000 acres of original forest. Approximately 10,000 acres, or one-half, lies within the boundaries of the territory occupied by the beech-birch-maple type.

The virgin forests that remain are typical of the type of forest that occupied nearby regions before logging and fire entered. The few virgin hardwood stands that may occasionally be seen are generally found growing in inaccessible locations from which it was possible to remove only the white pine and hemlock at a profit. This fact alone has served to preserve these old stands. A few additional old-growth hardwood stands occur as farmers' woodlots, but the aggregate of all such stands probably amounts to less than 10,000 acres. This means that virtually the entire production of the northern hardwood forest now comes from second growth or culled virgin stands. So often have these stands been culled that they are now composed of poor specimens of inferior species. Their yield, in both volume and quality, is far

below what forest owners and lumbermen may reasonably expect from this type of forest when it is managed after the manner of approved forest practice.

The area of second and third growth beech-birch-maple has been steadily increased. Following lumbering operations, these stands reproduce themselves substantially as they were. This fact indicates that because of the virtual exhaustion of virgin stands the area now occupied by beech-birch-maple will continue nearly constant and true to type. Beneath older stands of hardwoods the hemlock is beginning to re-establish itself. In the course of one or more rotations, with favorable conditions, the mixed forests of evergreens and hardwoods which our forefathers discovered in northern Pennsylvania, will return.

GROWTH HABITS OF BEECH-BIRCH-MAPLE FORESTS

Beech-birch-maple forests grow more rapidly than is generally believed. Lumbermen, forest land owners—even foresters—are among those who hold a mistaken opinion of the growth rate. This belief is based on data gathered largely in virgin stands or from trees that developed under conditions similar to the virgin forest. This mistaken opinion is easily understood and readily explained, in the light of new data.

The virgin forest was characterized by an extreme crown density. Fertile soils supported a large number of trees per unit of area. This fact, together with differing degrees of tolerance, which is the shade-enduring ability of a tree, gave rise to two-storied forests. Under the crowns of tall pines and the light-demanding hardwoods, hemlock, beech, birch, and maple grew with little difficulty, their crowns forming a highly efficient, wood-producing lower story. But while the total amount of wood produced was very large, the individual trees grew with extreme slowness, especially the more tolerant.

Many of the trees which ultimately won a place in the sun, did so only after a long struggle upward toward the light, as is evidenced by the markedly irregular thickness of the telltale annual rings. While other growth factors may also have influenced this, the aggregations of thin rings represent periods of suppression by shade, while the wide rings bespeak a more rapid growth under increased light condition. It is very obvious, then, that growth data based upon such stands are hardly more reliable than a superficial estimate.

In order to arrive at a more accurate and significant criterion of growth rate in the beech-birch-maple type in Pennsylvania, approximately 50 sample plots were established. The permanent plots are one-

Fig. 3. Nature Provides Excellent Reproduction Under Mature Stands of Beech-Birch-Maple Forests. More than 100,000 Small Trees per Acre, Ranging from a Few Inches to 6 Feet in Height, Were Counted Under This Excellent 90-Year-Old Stand in Potter County.

fourth acre in area. Located in different parts of the range of the type, they were carefully selected even-aged fully-stocked natural stands. These plots are not located in the very best, nor in the very poorest stands, but are situated so as to reflect the influence of average growth conditions. Growth figures collected from these stands show what may be expected from this type under favorable, but not unusual or ideal, natural conditions.

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INTENTIONAL SECOND EXPOSURE

The growth rate of these stands suffers none in a comparison with that of other forest types, although it varies considerably with the composition of the stand. A 40-year-old stand in Elk County, Pennsylvania, principally wild black cherry under which a second story of sugar maple developed, has been growing at the rate of 131 cubic feet per acre per year. In the same locality a 45-year-old stand, chiefly yellow birch, has grown at the rate of only 56 cubic feet per acre per year. Both grew under similar conditions. In addition to the wide difference in volume growth, these stands show a wide range in height and diameter growth.

The accompanying tables and graphs, based upon the measurements of trees found on 20 permanent sample plots, set forth the height and diameter growth of the trees of this important forest type.

Field studies show that the best rate of growth is made by mixed stands, that is, in stands in which the overstory is made up of the faster growing light-demanding trees such as wild black cherry, white ash, and basswood, and the understory consisting of sugar maple, yellow birch, and beech. By using simple silvicultural operations the composition of future stands of this type can be improved greatly. This will be reflected in an increased percentage of the more valuable species in the mixture, a greater density of stock, and a better form of the trees. Such improvements should speed the rate of growth.

Growth studies demonstrate that the beech-birch-maple type of forest grows rapidly in youth. The period of maximum height growth usually occurs before the fortieth and seldom after the sixtieth year.

AVERAGE AND MAXIMUM HEIGHT GROWTH OF BEECH-BIRCH-MAPLE TYPE IN NORTHERN PENNSYLVANIA

(Based upon 20 study plots)

Age (Years)	*Average Height (Feet)*	*Maximum Height (Feet)*
5	5	5
10	12	13
15	22	27
20	33	39
25	42	48
30	48	54
35	53	59
40	56	62
45	59	64
50	61	66
55	63	68
60	64	69
65	65	71
70	66	71
75	67	72
80	68	73

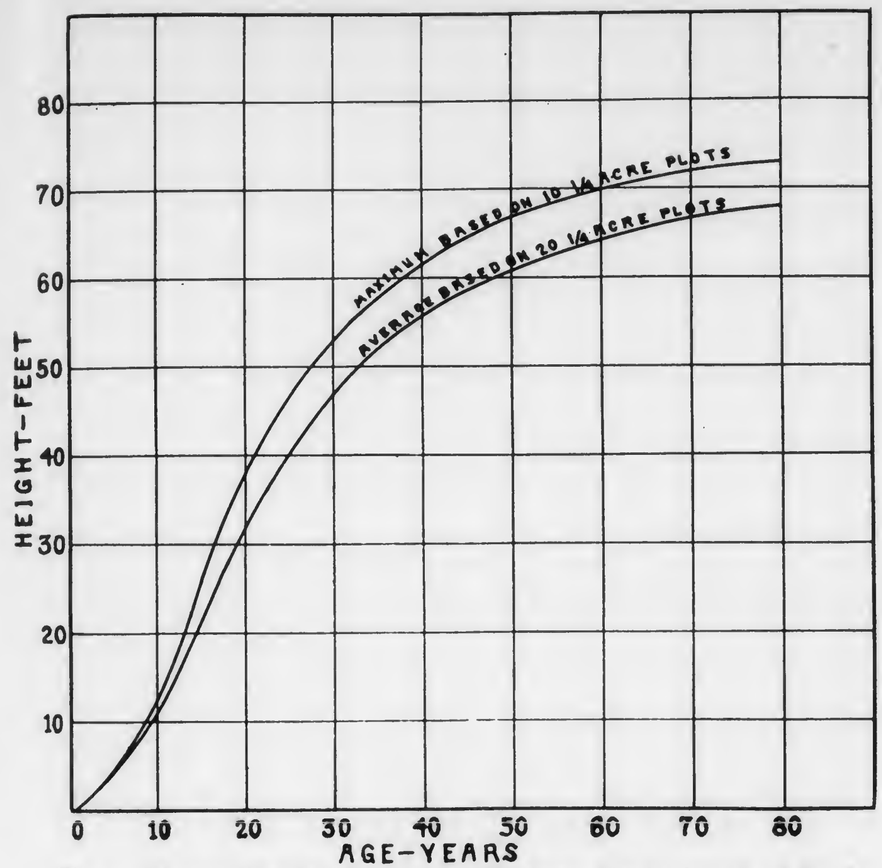


Fig. 4. Diagram Showing Average and Maximum Height Growth of Beech-Birch-Maple Type in Northern Pennsylvania at Different Ages up to 80 Years.

AVERAGE DIAMETER GROWTH OF BEECH-BIRCH-MAPLE TYPE IN NORTHERN PENNSYLVANIA

(Based on 18 permanent study plots)

Age (Years)	*Average Diameter (Inches)*
5	0.4
10	1.0
15	1.8
20	2.7
25	3.6
30	4.5
35	5.1
40	5.6
45	6.0
50	6.2
55	6.6
60	7.0
65	7.5
70	8.1
75	8.7
80	9.6

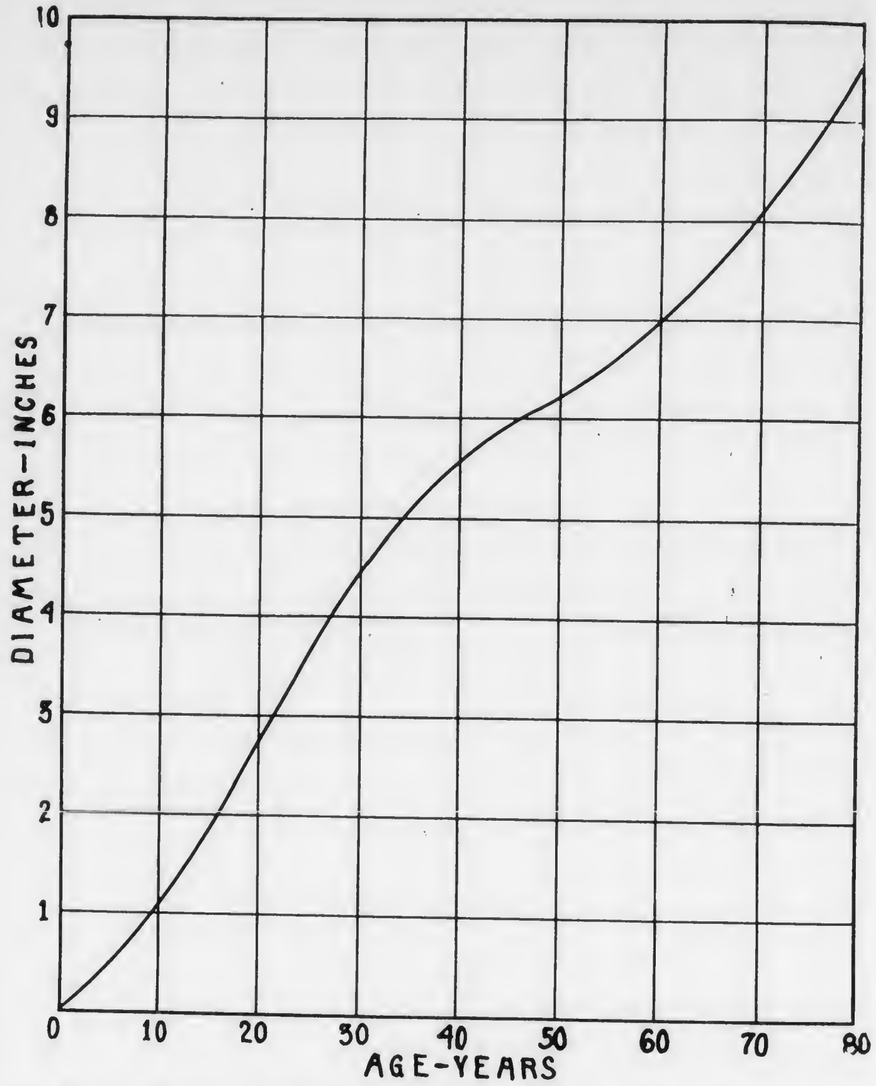


Fig. 5. Diagram Showing Average Diameter Growth of Beech-Birch-Maple Type in Northern Pennsylvania at Different Ages up to 80 Years. Based Upon 18 Study Plots.

The diameter growth appears to continue and often increases somewhat, holding its own for many years after the period of maximum height growth is passed. As soon as a retardation of growth is manifest in pure birch stands, heart rot begins to develop and such stands go to pieces. This is especially true of the black birch in pure stands. Wild black cherry, white ash, and basswood are not only fast growers, but often attain great size. The large size of wild black cherry in north-central Pennsylvania is attested by planks four feet in width sawed

from old-growth cherry logs cut on Cherry Ridge in Potter County. The more tolerant beech and sugar maple grow to a very large size and often attain great age. Measurements made on a chance wind-thrown sugar maple on State forest land in Potter County showed that it was almost 30 inches in diameter at breast-height. It was 111 feet tall and 51 feet to the first branch. Its estimated age was approximately 200 years.

YIELD OF BEECH-BIRCH-MAPLE FORESTS

A good system of forest tendance assures not only continuous but increasing returns from the forest so handled. Before any practical system of forest management can be instituted, it is essential to know the probable yield, which is the amount and character of products it is possible to obtain in a given period of time.

Our growth studies reveal that the average fully-stocked natural stand of beech, birch, and maple contains approximately as many cords per acre as it is old in years, within a certain definite period, beginning when stands are from 20-30 years of age and continuing for approximately 30 years, or until the age is 50-60 years. Natural stands cut during the period of maximum volume growth will yield one cord or more per acre per year of age, largely of cordwood material of a size suitable for chemical- and pulp-wood. Such stands as contain wild black cherry, white ash, and basswood will, after 40 years, often yield

AVERAGE AND MAXIMUM VOLUME GROWTH IN BEECH-BIRCH-MAPLE TYPE IN NORTHERN PENNSYLVANIA

Age (Years)	*Average Volume Per Acre*		*Maximum Volume Per Acre*	
	Cubic Feet	*Cords **	*Cubic Feet*	*Cords **
5	175	2.05	175	2.05
10	425	5.00	450	5.29
15	775	9.12	850	10.00
20	1,200	14.12	1,400	16.47
25	1,775	20.88	2,050	24.12
30	2,375	27.94	2,700	31.76
35	2,925	34.41	3,250	38.23
40	3,375	39.70	3,650	42.90
45	3,750	44.12	4,000	47.05
50	4,025	47.35	4,300	50.58
55	4,250	50.00	4,500	52.94
60	4,425	52.05	4,660	54.82
65	4,500	52.90	4,800	56.47
70	4,650	54.70	4,900	57.64
75	4,725	55.66	4,975	58.52
80	4,800	56.47	5.050	59.41

* Reducing factor from cubic feet to cords is 85 cubic feet equals one cord.

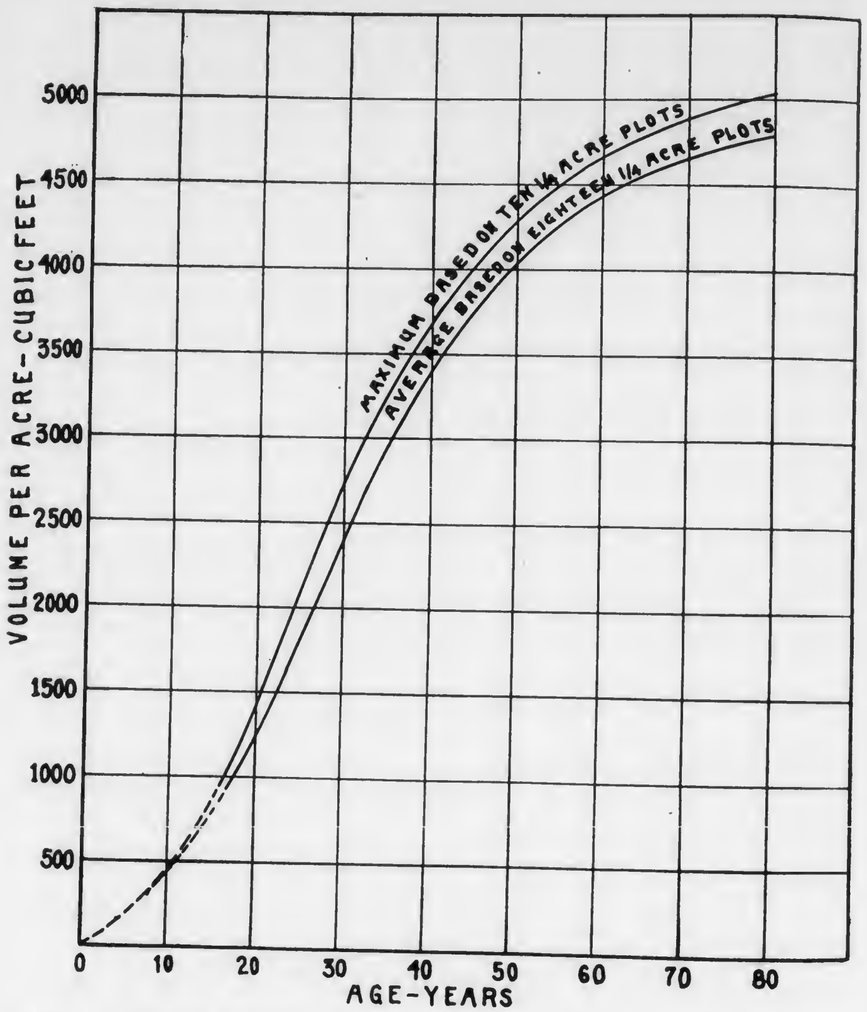


Fig. 6. Diagram Showing Average and Maximum Volume of Beech-Birch-Maple Type in Northern Pennsylvania in Cubic Feet per Acre at Different Ages up to 80 Years.

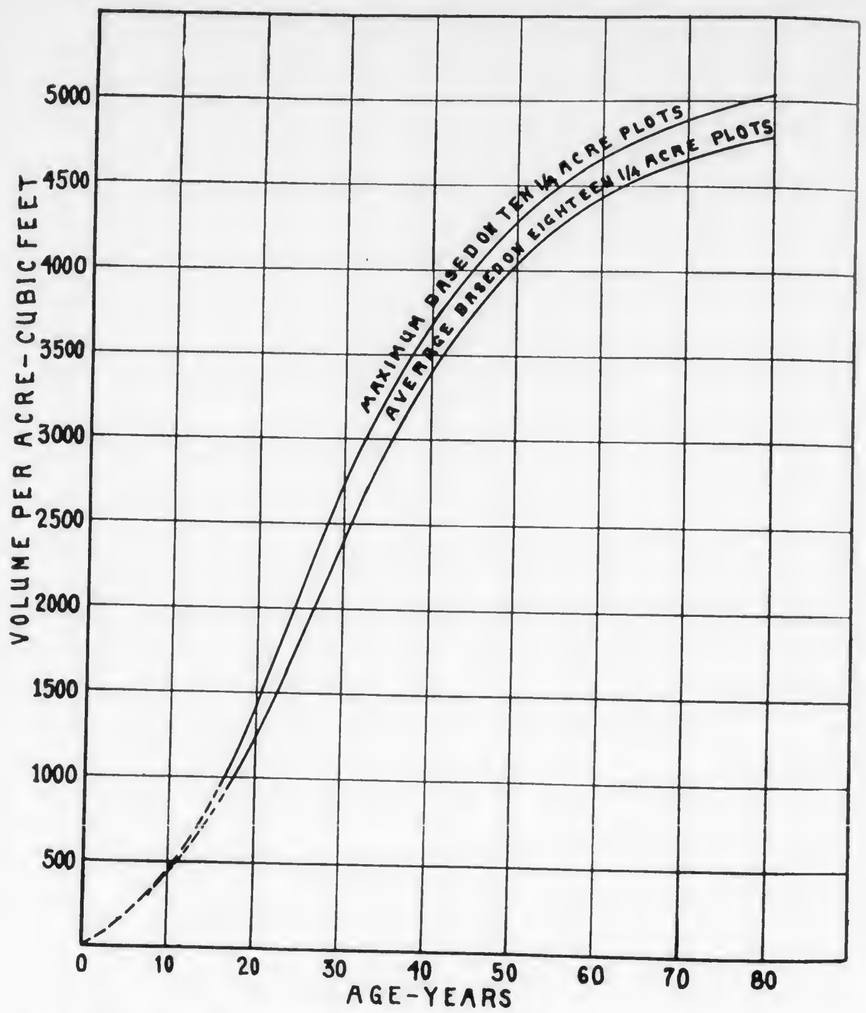
a considerable proportion of material of such size and quality as to be suitable for saw logs.

The accompanying table and graph, based upon data from 18 permanent sample plots, give the cubic foot volume yield per acre. The tables showing the yield in cords per acre were developed from the cubic foot yield tables. A converting factor of eighty-five cubic feet per cord was used.

After these stands reach an age of 60 years, the cubic foot volume growth increases rather slowly with the passing years. It is after this period of rapid height and volume growth is ended that much of the

Fig. 7. A 12-Year-Old Beech-Birch-Maple Stand Averaging 14 Feet in Height. It Contains Approximately 12,000 Trees per Acre

Fig. 8. An 18-Year-Old Beech-Birch-Maple Stand Containing 1,588 Trees per Acre. The Average Diameter (Breast-High) of the Trees Is Three Inches, Their Average Height 34 Feet, and Their Volume 1,599 Cubic Feet per Acre.



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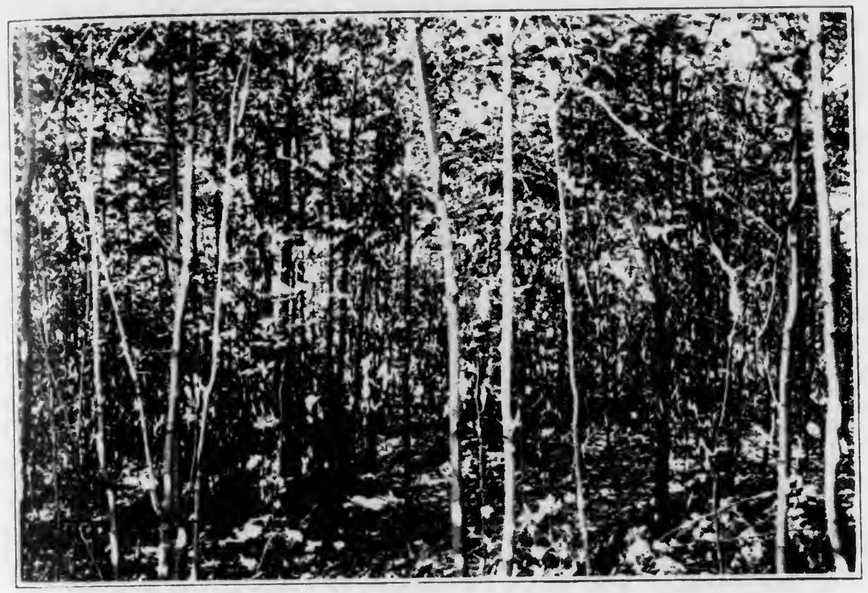

Fig. 7. A 12-Year-Old Beech-Birch-Maple Stand Averaging 11 Feet in Height. It Contains Approximately 12,000 Trees per Acre

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INTENTIONAL SECOND EXPOSURE

Fig. 9. A 26-Year-Old Mixed Stand of Yellow and Black Birch Averaging 3.4 Inches in Diameter, and 39 Feet in Height. It Contains 1,264 Trees per Acre with a Total Volume of 1,705 Cubic Feet.

Fig. 10. A 30-Year-Old Stand, Principally Black Birch, Averaging 3.4 Inches in Diameter and 40 Feet in Height. It Contains 1,476 Trees per Acre with a Total Volume of 2,223 Cubic Feet.

Fig. 11. A 40-Year-Old Stand, Principally Wild Black Cherry and Sugar Maple, Averaging 6.5 Inches in Diameter and 62 Feet in Height. This Stand Contains 680 Trees per Acre with a Total Volume of 5,254 Cubic Feet.

Fig. 12. A 62-Year-Old Stand, Principally Yellow Birch and Black Birch, Averaging 5.4 Inches in Diameter and 72 Feet in Height. This Stand Contains 724 Trees per Acre with a Total Volume of 4,612 Cubic Feet.

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Fig. 10. A 30-Year-Old Stand, Principally Black Birch, Averaging 3.4 Inches in Diameter and 40 Feet in Height. It Contains 1,476 Trees per Acre with a Total Volume of 2,223 Cubic Feet.

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Fig. 13. An 80-Year-Old Beech-Birch-Maple Stand Averaging 71 Feet in Height and 9.6 Inches in Diameter. This Stand Contains 264 Trees per Acre with a Total Volume of 4,854 Cubic Feet.

quality growth occurs. In the average fully-stocked natural stand at 60 years of age, trees possess a bole free of limbs for 40 to 50 feet, so that all wood laid on thereafter will be absolutely clear. Lumber from such stands is of the highest quality, naturally commanding the best prices.

AVERAGE NUMBER OF TREES PER ACRE IN 5- TO 80-YEAR-OLD STANDS OF BEECH-BIRCH-MAPLE TYPE IN NORTHERN PENNSYLVANIA

Age (Years)	*Number of Trees Per Acre*
5	30,000
10	8,750
15	5,000
20	1,650
25	1,150
30	900
35	750
40	650
45	575
50	525
55	450
60	425
65	375
70	350
75	325
80	300

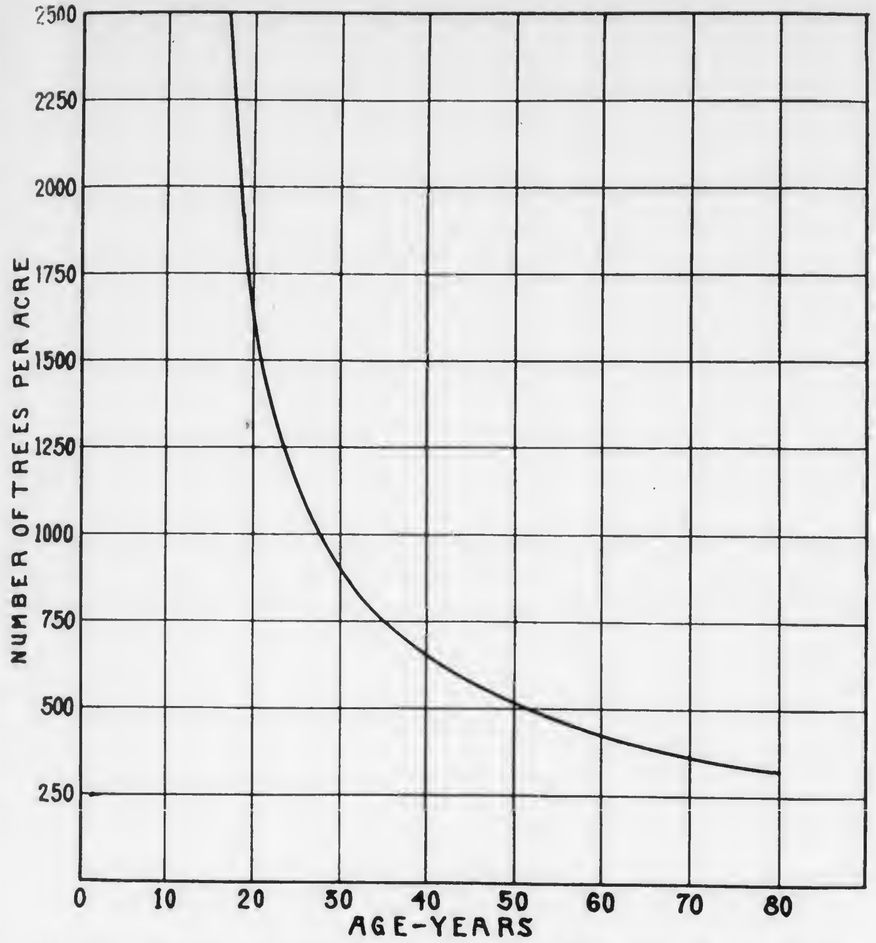

Fig. 14. Diagram Showing Average Number of Trees per Acre in Beech-Birch-Maple Forest Stands of Northern Pennsylvania at Different Ages up to 80 Years.

Stands cut at 60 to 80 years will yield approximately 5,000 cubic feet, with a good percentage of the wood yield suitable in size and quality for saw timber. An estimate places the percentage of saw timber in such stands at 50-80 per cent of the total volume.

As the age and size of trees increase, a still further reduction in numbers takes place, through natural or artificial selection. With fewer stems of larger size feeding from the soil, the tendency is more and more toward quality production, with excellent yield in fine saw lumber. The accompanying table and graph, derived from 24 sample plots, show how rapidly the number of trees per acre decreases with age.

It was exceedingly difficult to find even-aged fully-stocked natural stands exceeding 45 years of age, for it was within that span of years

Fig. 13. An 80-Year-Old Beech-Birch-Maple Stand Averaging 71 Feet in Height and 9.6 Inches in Diameter. This Stand Contains 264 Trees per Acre with a Total Volume of 4,854 Cubic Feet.

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Age (Years)	*Number of Trees Per Acre*
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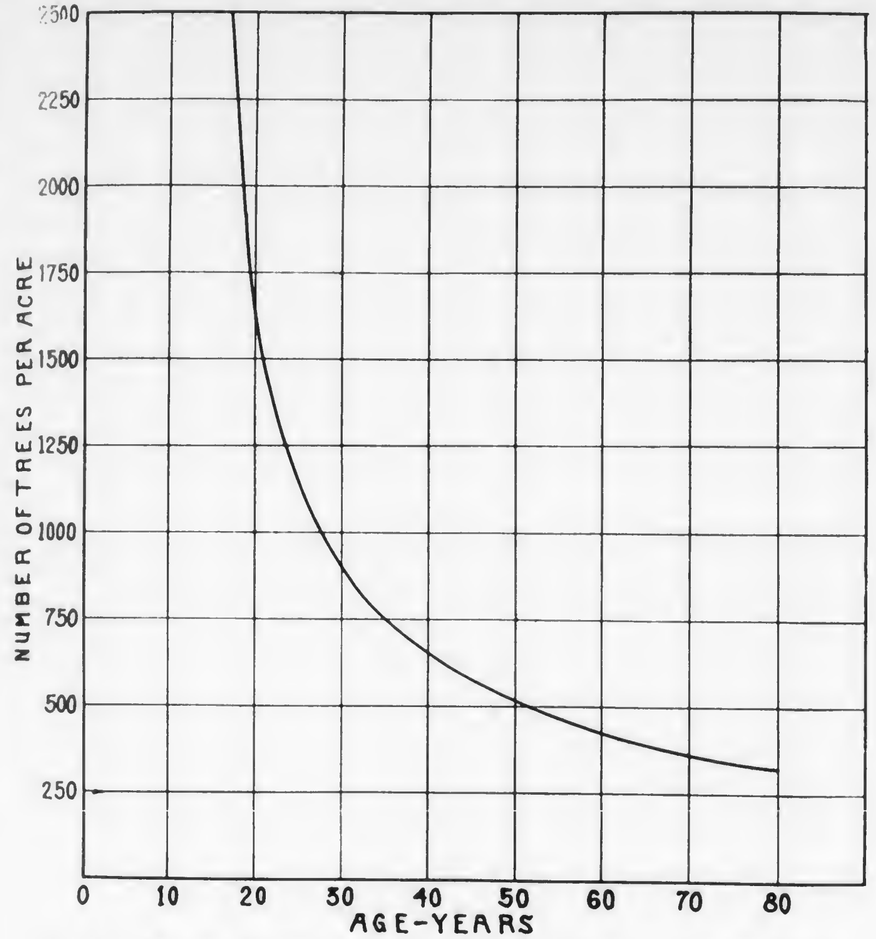
30	900
35	750
40	650
45	575
50	525
55	450
60	425
65	375
70	350
75	325
80	300



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INTENTIONAL SECOND EXPOSURE

that the original stands were cut cleanly, then permitted to grow again. This explains why no attempt was made to work out the actual board foot yield of beech-birch-maple stands.

Data supplied by Robert Lyman, forester of the Gray Chemical Company, and collected from a natural even-aged 25-year-old beech-birch-maple stand in Potter County, showed a yield of 23 stacked cords of chemical-wood per acre. Similar stands of 45 and 80 years yielded, respectively, 45 and 79 stacked cords. These records tend to confirm data from the Department's permanent sample plots.

Yield data based on the actual volumes of even-aged fully-stocked natural stands, as these are, represent the minimum yield to be expected under a system of good forest tendance.

BEECH-BIRCH-MAPLE PRODUCTS

Products supplied by the beech-birch-maple, or northern hardwood forests, have always been of lesser amount and value than products of the softwoods. In the past, these hardwood species contributed little to industry, such as general construction or box or paper making, which require wood in large quantities.

Pennsylvania's huge wood reservoir is almost empty. The passing of the virgin forests results in an ever-diminishing production of both softwoods and hardwoods. While the rate of cutting on both has been slowing up, the proportionate amounts of each class have been changing rapidly. In 1900 about 75 per cent of the timber cut in Pennsylvania was softwoods. In 1923, 64 per cent was hardwoods. By 1935, it is estimated, 75 per cent or more of the total cutting in the State will be of hardwoods. Accordingly, it may be expected that hardwoods will substantially supplant the softwoods where the latter once were considered essential to industry.

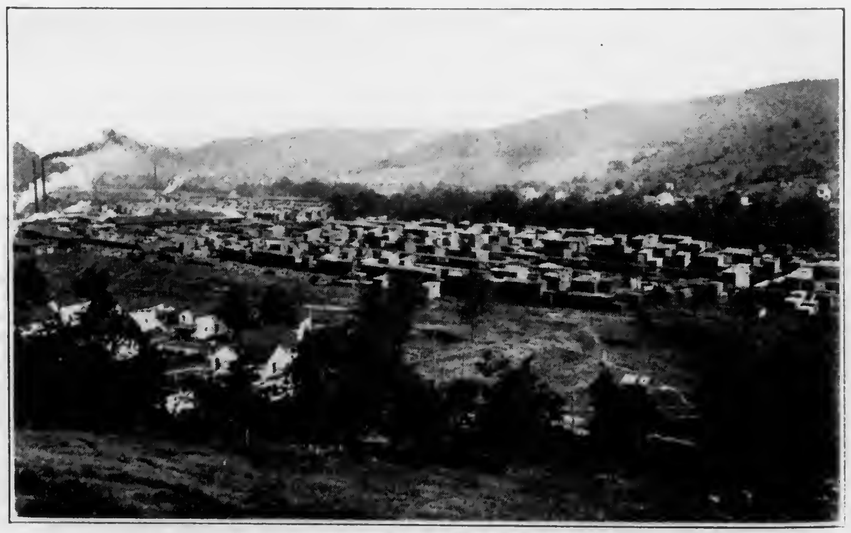

Fig. 15. One of Pennsylvania's Big Sawmills Located in the Beech-Birch-Maple Forest Region at Sheffield, Warren County

Woods furnished by the beech-birch-maple forests are indispensable for hundreds of uses, which are none the less important because a relatively small supply is required for the specific need. Many of these products are intimately associated with our daily lives.

The principal products derived from these forests are lumber, pulp- and chemical-wood, fuel-wood, syrup and sugar of the maple, and, in small amounts, natural birch oil.

Fig. 16. A Hardwood Distillation Plant Located in the Heart of the Beech-Birch-Maple Forest in North-Central Pennsylvania

LUMBER

Important among the lumber uses of these trees are interior finishings, flooring, furniture, turning stock, novelties, woodenware, handles, shuttles, bobbins, spools, vehicles, veneer, baskets, and boxes. There are many other uses. Eighty-one distinct articles are listed as being manufactured from sugar maple alone. Articles made from the wood of these trees are almost unlimited in number. Because these articles are so widely and commonly used, one is prone to overlook the source of them. Among them are many of the common comforts of life.

CHEMICAL-WOOD

Lumber and other products manufactured from these forests are important enough now; but that the future holds a still wider and more varied demand may be expected. One of the chief demands at present, which is supplied largely by culled and second growth stands, is for chemical-wood. Sugar maple is the most desirable species. From these trees the chemist secures a large number of the drugs of the pharmacist, explosives so necessary to the engineer in blasting his way through mountains, alcohol for power, and many other products. Low grade and small material from the forest is thus profitably utilized. Recent developments in industry point toward a steady future demand for this class of material.

The very fact that chemical science utilizes beech, birch, and maple woods of small size, inferior quality, and trees of poor form is an eloquent reason for regarding this type as most promising for forest management. Forestry has never been highly profitable or truly conservative, and indeed will not be, without complete utilization. Wherever stands of this type are accessible, thinnings are practicable now. The future will surely increase the profits from this source.

PULP-WOOD

Softwoods have always been the most important source of raw material for the manufacture of paper. With the disappearance of the hemlock, the industry in this State has been turning toward these hardwoods as a future source. In this, and in the chemical-wood industry, recent developments point to new heavy demands for raw material—a demand certain to be further strengthened by the improved methods now in use, and recently-perfected ones for reducing these woods to pulp.

Fig. 17. A Wood Yard with About 100,000 Cords of Chemical-Wood Stored At a Hardwood Distillation Plant in McKean County, Pennsylvania

Although a relatively small amount of wood is required for each of its special uses, compared with the amount of softwoods used in general construction, the aggregate is great and constantly increasing. An important factor contributing to further increased demand is the competition of hardwoods with softwoods in the field of utility once dominated by the latter. Lumber manufactured from these hardwood trees is growing more important in construction work.

These trees yield woods that are compact or solid, comparatively heavy, and well suited to fuel purposes. Of all the species found in this type, beech produces the most desirable fuel-wood; and as the greatest and most extensive beech-birch-maple forests occur outside of the limits of the coal measures, these woods form important sources of local fuel supplies.

MAPLE SYRUP AND SUGAR

The making of some "sugar bushes" into lumber, with the natural deterioration of other such stands, brought about by neglect, has resulted in a decrease in the amount and value of the products of the sugar maple industry in the State. Pennsylvania maple syrup and sugar are excellent in quality and generally bring top prices.

This subordinate by-product of forest practice in Pennsylvania produced, in 1926, a revenue of $594,000 from approximately 223,000 pounds of sugar, and 251,000 gallons of syrup.

BIRCH OIL

Another secondary product of this forest type is natural birch oil, which is used for flavoring and in medicines. It is distilled from the inner bark of the sweet or black birch (Betula lenta). Since the branch-wood and twigs are the most desirable parts for distillation purposes, young open-grown trees or those having large wide crowns are preferred. With the branch- and limb-wood and twigs utilized to advantage, this industry offers a practical method of using profitably the waste from lumbering operations and improvement cuttings.

UTILIZATION INFLUENCE ON THE FOREST

Utilization is one of the prime factors in forest management. Upon the method and kind of utility practiced rests, not only success or failure in establishing new stands to replace those removed, but the quality of the new stands. By quality is meant stands fully stocked with the most desirable species.

Under present methods the best and largest trees become saw logs. Material of smaller size is worked into cordwood, which is used by the chemical and wood-pulp industries.

Even the poorest species commonly found in culled beech-birch-maple stands are now so valuable as a source of raw material for chemical and pulp-wood operations, and of wood for similar purposes, that clear-cutting is the rule. Because of the complete utilization, little is left on an area, following a completed lumber and chemical-wood operation, except small brush.

PRESENT CUTTING METHODS

Occasionally, even at the present time, utilization is practiced much as it was years ago, in that only the best trees of the most desirable species are removed. This is especialy true in operations that are remotely located, where transportation is a costly problem. From observations made in the field, this system is much more to be condemned than is clear-cutting of the older stands, in so far as it affects reproduction. It leaves only the malformed misshapen and often stagheaded specimens. Their crowns intercept light, their root systems occupy the soil, and thus they prevent the development of valuable young stands.

Fig. 18. A Typical Cut-Over Area After Beech-Birch-Maple Stands Have Been Lumbered for Chemical-Wood. The Cut-Over Lands Appear to Be Devastated but if Protected Against Fire Will Soon Become Well Stocked with Small Trees.

CLEAR-CUTTING

Where old growth stands are cut and fire is kept out of the woods, excellent fully-stocked even-aged natural stands of valuable young trees develop. Studies show that fine young stands of beech, birch, and maple, which follow clean-cutting operations in old-growth hardwoods, are already established on the forest floor previous to the cutting operations. Likewise, most of the seed that germinates after old stands are removed, is already present in the duff of the forest floor. The invisible forest needs only light to begin active growth.

Fig. 19. The Same Area Shown in Fig. 18 Four Years After Lumbering. As Many As 32,452 Small Trees Were Counted per Acre

There is little desirable reproduction present under beech-birch-maple stands that are less than 50 years of age. In the dense fully-stocked natural stands the shade cast by the crowns, until these trees reach the half-century mark, is nearly always too heavy to permit much vigorous young growth to start. On the other hand, field studies frequently show a considerable number of seedling trees present under stands that range from 20 to 50 years of age. After struggling in a heavy shade, many of these seedlings die when the stand is opened and light let in.

Also, this young growth lacks the vigor necessary to compete successfully with sprout growth from the freshly-made stumps. In stands

that were less than 50 to 60 years of age when lumbered, most of the reproduction will be of sprout origin.

Although sprout growth starts more quickly than seedling, it is much less desirable, because sprout growth begins to go to pieces, and the stands break up, at an early age. Most of the hardwood stumps sprout freely and vigorously, especially when cutting is done during the period of vegetation dormancy; yet with few exceptions, thrifty sprouts are produced only from the smaller stumps.

Growth studies demonstrate that in longevity, size, and quality, seedling stands are superior to those of sprout growth. To secure seedling or seedling-sprout reproduction of desirable species after a chemical-wood operation in stands of less than 40 to 60 years, requires some system of management other than wholesale clear-cutting. Unless the latter method is discontinued, stands already poor will continue to degenerate.

MODIFICATION OF CLEAR-CUTTING

While clear-cutting in its present form is to be discouraged, under certain conditions a modification of clear-cutting is justifiable and proper, especially when there is good promise of seedling or seedling-sprout reproduction of the desired species.

Any attempt to utilize dense fully-stocked even-aged stands under a system of forest tendance other than clear-cutting, will be difficult and costly. Individual trees in such stands being virtually all the same size, possess long slender boles, and depend upon each other for protection and support. Partial cutting in such stands results in windfall and damage from snow and ice. Clear-cutting is not only cheaper, and consequently more profitable, but if modified properly, results in reproduction which produces improvement in kind and quality of reproduction.

It must be remembered that improved reproduction results when a modification of the clear-cutting system is employed, the area that is cut clear being of comparatively small size. To accomplish this, cutting may be done in strips, blocks, groups, or patches, whichever method in the forester's judgment seems best with regard to the nature of the land or other growth factors. Modifications in the application of clear-cutting methods present a wide range of possibilities. If the strip method is used, the clear-cut strips may be narrow or wide, and arranged progressively or alternate with uncut strips. A wide range of application is also possible in locating the blocks, groups, and patches, which may range in size from very small to substantial areas, depending upon the intensity of management. As a rule, the more intensive the management the smaller are the strips, blocks, groups, and patches cut over in a single cutting. The tendency in approved forest practice is away from the large clear-cut area.

By cutting the desired species during a heavy seed year and the undesirable species in an off year, it may be possible in a measure to modify the composition of future stands. The effect such a procedure will have on the subsequent stands is uncertain because most of the seedlings that spring up following lumbering were already present on the forest floor before the cutting began.

Insurance against failure of reproduction because of fire or other causes can be provided if clear-cutting is scattered over large areas. The final strips or blocks of old growth should not be removed until adjacent stands of young trees have become well established.

THE SELECTION SYSTEM

The selection system of handling forest stands is very well adapted to the beech-birch-maple forest type. It is the natural method and is especially adapted to producing a large volume of desirable kinds of wood. Another advantage of the careful selection and removal of trees or tree groups is the opportunity afforded to control the make-up of subsequent stands. If applied properly, the selection cuttings make possible the development of a progressive program of forest improvement.

In the past, the best trees of preferred species were removed at each cutting of virgin and culled forests. This resulted in a constant deterioration of the quality of the forest stands. Selection cuttings tend to build up volume and quality production, and improve growth conditions.

While the selection system may not appear to work so well from the logging angle, it can be developed along practical lines. A modification of this method, such as group selection, presents a wide range of possibilities and ties in rather closely with the group clear-cutting method. Under the group selection method, trees are cut in small groups. By this method large openings in the forest are avoided. The advantages of maintaining a group-wise arrangement of trees is that less breakage among the young trees is caused in felling and removing the oldest-aged class. The cost of logging is usually lowered and at the same time more light is provided for the development of young trees.

In a forest which supplies necessary products that are in constant demand, repeated cutting and cultivation through modern methods, field studies demonstrate, speed up growth and improve the quality of the lumber. Aside from this, the huge quantities of small-sized material produced in lumbering is made available to meet a present big demand. Assurance of a steady supply, observation teaches, serves to increase the demand and encourages expansion of industry.

This, considered with the demand for secondary products of the

maple and the birch, is an added incentive; in fact, it is an economic reason for the practice of more intensive forest management. More and better forests must follow in natural course.

BRUSH DISPOSAL

Demand for small low-grade material means that even the branchwood is utilized down to small dimensions. The debris from lumbering is all of small size. In present operations this is piled in windrows, to give clean spaces in which the men may work. Field studies show that this material begins to decay three years after lumbering, and by the

Fig. 20. A Typical Chemical-Wood Cutting Operation in Potter County

eighth year little remains except small portions of the large material, usually in a rotten or semi-decayed condition. The fire hazard is greatest in the first two to five years following a lumbering operation. It becomes less each year thereafter until about the eighth or tenth year, when there is practically none, except for an occasional spring season with unusually cold dry weather conditions. Ordinarily, sugar maple and birch establish a dense leaf canopy before the forest floor dries out enough to be inflammable.

To determine just how fires influence the forest is a big problem in itself and requires much study. As this bulletin is concerned chiefly with growth and yield, the effects of fire dealt with here are confined

to noting the loss of time in rotation, particularly in the reproduction period.

When fires occur and there are no seed trees in the immediate vicinity, a complete restocking with valuable trees is a long and tedious process. In many cases the time lost through such fires varies from a few years (two or three in some cases), to 30 or more years, when seed trees or old stands are found only at a long distance from the burned area. Most of the trees in the beech-birch-maple type sprout rather weakly after forest fires, as compared to oak, hickory, elm, black locust, and certain other hardwoods. Their wood is also rather subject to decay, notably in the sap zone, which renders fire-coppice or sprouts unsatisfactory as the basis of a new stand.

REPRODUCTION OF THE BEECH-BIRCH-MAPLE TYPE

The beech-birch-maple forest type employs three important methods of reproduction. Maple and birch seed freely and sprout vigorously. The beech seeds less frequently and sprouts less vigorously, but possesses a compensating factor in its production of vigorous root-suckers in large numbers. The associated species, namely, wild black cherry, white ash, and basswood, also seed frequently, producing large crops of viable seed.

This seed begins to develop in early summer and matures in September and October. Much of the seed falls from the parent tree as soon as it matures. There is, however, a strong tendency on the part of a number of the species found in this type to retain a portion of their seed until mid-winter or early spring, when the small winged seed is blown about and widely scattered by the strong winds. This is true of the birches and to a lesser extent of the basswood and the white ash.

SEED

Seeding is the most important method by which the birches reproduce. They bear large quantities of viable seed each year. The birches are less tolerant than the sugar maple or the beech. Their light winged seed is widely dispersed by the wind, and wherever conditions are at all favorable, seedlings develop. The seed of the birches is able to germinate and to establish itself on bare mineral soil, among rocks, and even on rotting logs and stumps and on decaying duff of the forest floor. Seed falling on top of the snow in winter, especially on rocky areas, is carried by the melting snow in spring, down among the crevices of the rocks, where it later germinates and young trees develop. Due to this characteristic, birches are enabled to gain a foothold on very rocky and inhospitable areas.

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REPRODUCTION OF THE BEECH-BIRCH-MAPLE TYPE

The beech-birch-maple forest type employs three important methods of reproduction. Maple and birch seed freely and sprout vigorously. The beech seeds less frequently and sprouts less vigorously, but possesses a compensating factor in its production of vigorous root-suckers in large numbers. The associated species, namely, wild black cherry, white ash, and basswood, also seed frequently, producing large crops of viable seed.

This seed begins to develop in early summer and matures in September and October. Much of the seed falls from the parent tree as soon as it matures. There is, however, a strong tendency on the part of a number of the species found in this type to retain a portion of their seed until mid-winter or early spring, when the small winged seed is blown about and widely scattered by the strong winds. This is true of the birches and to a lesser extent of the basswood and the white ash.

SEED

Seeding is the most important method by which the birches reproduce. They bear large quantities of viable seed each year. The birches are less tolerant than the sugar maple or the beech. Their light winged seed is widely dispersed by the wind, and wherever conditions are at all favorable, seedlings develop. The seed of the birches is able to germinate and to establish itself on bare mineral soil, among rocks, and even on rotting logs and stumps and on decaying duff of the forest floor. Seed falling on top of the snow in winter, especially on rocky areas, is carried by the melting snow in spring, down among the crevices of the rocks, where it later germinates and young trees develop. Due to this characteristic, birches are enabled to gain a foothold on very rocky and inhospitable areas.

INTENTIONAL SECOND EXPOSURE

Although the sugar maple is not an annual seeder, it does bear heavy crops of seed at frequent intervals. As with the birches, seeding is the most important method of reproduction. Sugar maple appears to establish itself most successfully in the neutral duff formed of decayed beech leaves under relatively dense shade. As a result, areas of thrifty and dense sugar maple reproduction occur under old stands in which beech forms a considerable proportion of the mixture.

Under such a stand in Potter County, averaging approxmiately 60 years of age, several reproduction plots have been established. The forest floor was uniformly occupied by a vigorous and dense growth of small sugar maple ranging in age from one to six years. These trees occupy this site almost to the exclusion of other trees. A plot 10 x 10 feet square, contained 462 sugar maple, 14 beech, 9 wild black cherry, and 51 striped maple trees.

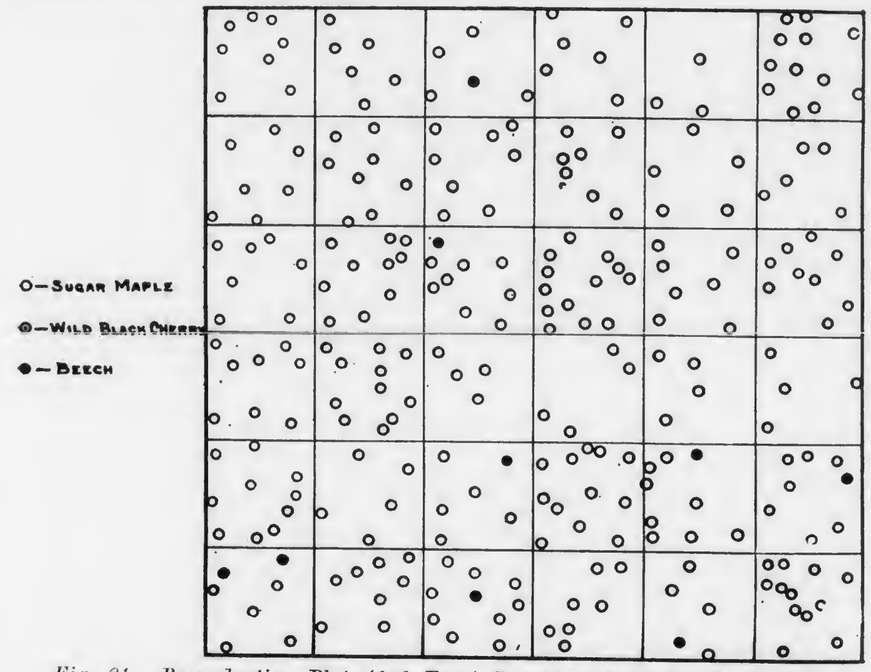

Fig. 21. Reproduction Plot (6x6 Feet) Located At About the Center of Fig. 23. Each Square Block Represents a Square Foot of Surface Area on the Forest Floor. It Shows the Number and Distribution of the Small Sugar Maple, Wild Black Cherry, and Beech Trees on a Plot That Is Typical of Large Areas in the Northwoods.

This shows the extreme density of the reproduction of this species as compared with the numbers of the seedlings of beech and other trees. Reproduction studies show that the sugar maple, at least in its seedling and small sapling stage, is the most tolerant of the species characteristic of the beech-birch-maple type.

Small sugar maple saplings were observed that had grown as much as three and one-half feet in a single season, under a hardwood stand approximately 125 years of age. A count of the species and numbers of trees on several reproduction plots under this same stand revealed more than 100,000 small sugar maple trees per acre. They ranged in height from six inches to five feet. These studies also showed 436 beech, 3,915 wild black cherry, and 3,045 white ash trees per acre. The latter species of trees were, on the average, smaller than the sugar maple. Field notes show that the sugar maple is ordinarily the most aggressive reproducer in the beech-birch-maple type, doubtless because of its extreme tolerance and its excellent seeding qualities.

ROOT-SUCKERS

Beech trees produce large crops of nuts only at two- or three-year intervals. The nuts are comparatively large and palatable and much of the seed produced is devoured by animals. The beech is second only

Fig. 22. A 40-Year-Old Stand, Principally Beech of Root-Sucker Origin, and Sugar Maple, Averaging 4 Inches in Diameter and 38 Feet in Height. This Stand Contains 976 Trees per Acre with a Total Volume of 1,977 Cubic Feet.

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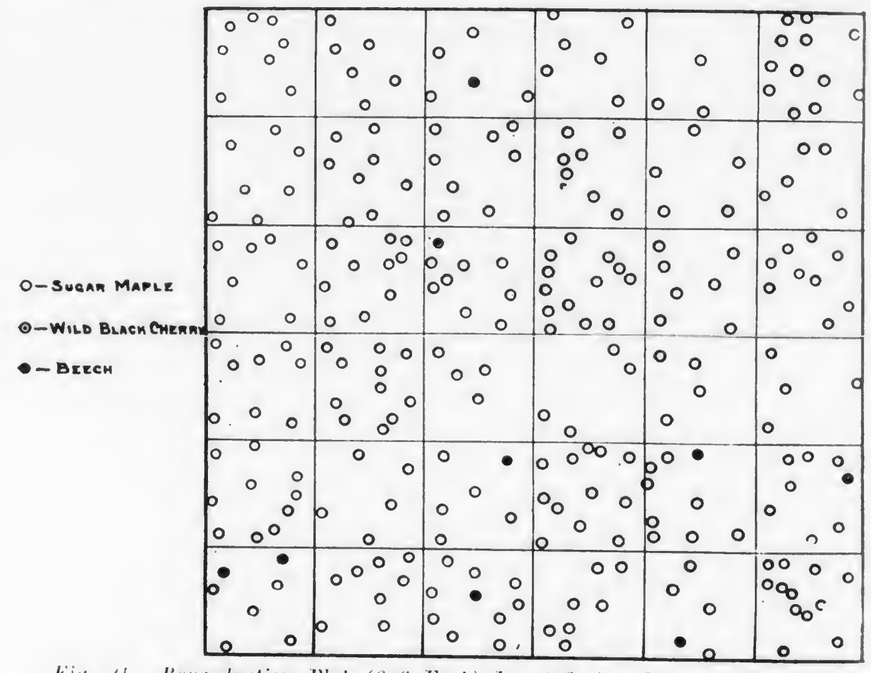

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INTENTIONAL SECOND EXPOSURE

beech of root-sucker origin is located near Dushore, Pennsylvania. A permanent sample plot has been established in this stand. Field notes prove that this method and seed reproduction are the two successful methods of reproducing beech.

Wild black cherry, basswood, and white ash often produce seed in abundance. These trees do not, however, bear heavy crops of seed every year, neither is their seed so widely distributed. Ordinarily they require much more light for germination and growth than do other important trees common to the beech-birch-maple type.

SPROUTS

Sprouting from the stump is a method of reproduction common among all the trees of this type. Sprouts from small stumps are vigorous. At times sprouts from large basswood and wild black cherry stumps develop into fair-sized trees. However, stands of sprout origin too often break over and go to pieces at an early stage. Studies show that the cleanest fastest-growing and best-formed trees are found in

Fig. 23. Under This Mature Beech-Birch-Maple Stand Were Counted More Than 300,000 Small Trees per Acre Ranging from 4 to 11 Inches in Height

stands that have developed from seedling or seedling-sprout growth. By seedling-sprout growth is meant small seedlings and saplings that have been cut or broken off near the ground level when the old stands were lumbered. Under a permanent system of forest tendance in Pennsylvania, stands of this type should be so handled as to procure reproduction of seedling origin.

Studies show that the densest stand of seedling trees was composed of wild black cherry. On an area of one square yard 177 wild black cherry trees were found near Wilcox in Elk County. This is at the rate of more than 800,000 per acre. The plot was established under an overstory of wild black cherry, sugar maple, beech, and hemlock, named in order of numerical importance in the stand, which is approximately 150 years of age. Small seedlings average four to 10 inches in height and were from one to five years of age.

ARTIFICIAL RESTORATION

Field observations and notes show that where lumbering first took all old-growth timber, and successive fires have destroyed young growth over large areas, planting is the only recourse left.

Nursery and planting records show that a total of more than 2,500,000 trees characteristic of this forest type, including approximately 2,000,000 white ash, nearly 500,000 sugar maple, and more than

Fig. 24. Lumbering Followed by Repeated Burnings Have Made Planting Necessary on This Site in the Beech-Birch-Maple Region of Pennsylvania

50,000 wild black cherry, have been planted in Pennsylvania. Other hardwood trees characteristic of the type have been grown in our nurseries only in an experimental way.

If a region is best suited to growing beech, birch, and maple, or is now occupied by this type, but was originally stocked with stands of mixed hardwoods and conifers and is in need of restocking, it should be planted preferably to softwoods native to the region. In time the hard-

woods, because of their more mobile seeds and aggressiveness will again become established. In the course of one or more rotations, such stands will resemble those originally provided by nature, namely, mixed hardwoods and softwoods. Because of its more rapid growth, greater volume production, and better silvicultural conditions, this mixture is the most desirable possible to obtain.

SUMMARY

1. Beech-birch-maple type is the term used to describe that general forest condition encountered in northern Pennsylvania in which the forests are composed chiefly of beech, birch, and maple trees. The principal trees in the type are: sugar maple, yellow birch, black birch, and beech, with important associated trees, such as wild black cherry, white ash, and basswood. This natural grouping of trees is sometimes described as the northern hardwood forest.

2. The beech-birch-maple forest type is distinctly northern, very important in the Lake States, the Adirondacks, New England, and northern Pennsylvania, particularly in the counties of Potter, McKean, Forest, Tioga, Elk, Cameron, Lycoming, and Sullivan. Other extensive areas occur in Wayne, Susquehanna, Bradford, Monroe, Clearfield, Cambria, and Somerset Counties. Widely-detached outposts are found in Franklin and Lancaster Counties. (See map showing distribution of the beech-birch-maple type in Pennsylvania, on page 8.)

3. The area of the beech-birch-maple region in Pennsylvania occupies nearly 7,372,800 acres. Large continuous tracts in north-central Pennsylvania cover a total area of 4,352,729 acres. Broken or farm woodlot areas, and the region where the oak-chestnut grows in mixture with the beech-birch-maple type form together an area of 3,170,071 acres.

4. The present range of the beech-birch-maple type in Pennsylvania corresponds to the original white pine and hemlock forests, in which grew scattered specimens and small groups of beech, birch, and maple.

The spruce-fir, the white pine-hemlock, and the aspen-fire cherry types are found in the same regions as the beech-birch-maple type.

The beech-birch-maple type grows best at elevations of 1,000 to 2,500 feet, where the normal annual rainfall totals 40 to 50 inches, and the annual mean temperature is 44 to 49 degrees.

5. The original forest of north-central Pennsylvania was composed of a dense growth of white pine and hemlock, mixed with sugar maple, black birch and yellow birch, beech, wild black cherry, ash, and basswood. When the virgin forests were first lumbered, white pine and hemlock were the most valuable trees, and were cut most heavily. The hardwoods were favored, not only by being cut less heavily, but by being more resistant to fire and more aggressive reproducers. Hence, they took possession of the areas they now occupy, almost to the exclusion of softwoods.

6. The disappearance of white pine and hemlock from vast areas in the northern forest region is due to the great fires that have followed lumbering. If fire is kept out of beech-birch-maple stands, where scattered softwood seed trees are available, young softwoods will establish themselves under the protection of the overstory of hardwoods. The hemlock—one of the most tolerant of all native trees—develops under comparatively young hardwood stands. White pine, less tolerant, does not begin to develop in the same stand until the hardwood is older, when openings develop between the crowns and permit more sunlight to reach the forest floor. Proper handling assures this desirable hardwood-softwood mixture.

7. The beech-birch-maple type grows more rapidly than it is generally believed. Maximum height growth usually comes before the fortieth, and seldom after the sixtieth, year. Growth in diameter not only continues, but holds its own and even increases for many years after maximum height growth is past. Greatest volume growth is made between the twentieth and sixtieth years. After the sixtieth year, the total volume growth increases very slowly. However, most of the quality growth comes after the period of maximum volume growth is past.

8. The best rate of growth is made by mixed stands, in which the overstory is composed of such rapid-growing light-demanding trees as wild black cherry, ash, and basswood, among and under which sugar maple, yellow birch, and black birch develop. In Elk County, a 40-year-old stand, chiefly black cherry, grew at the rate of 131 cubic feet per acre per year. In the same locality a 45-year stand, dominated by yellow birch, produced only 56 cubic feet per acre per year. Both grew under similar conditions. The best mixture is softwoods and hardwoods of all degrees of tolerance, similar to those nature originally provided.

10. Natural even-aged fully-stocked stands of beech-birch-maple, beginning at the twentieth to the thirtieth year and continuing to the fiftieth or sixtieth year, will yield one cord or more of wood per acre per year. Because of the relatively small average diameter attained by the individual trees in these stands, the yield of a stand younger than 40 to 60 years is best suited to chemical-, pulp-, and fuel-wood. Stands 60 to 80 years of age will yield approximately 5,000 cubic feet. The quantity of saw timber in such stands ranges from 50 to 80 per cent of the total volume. With a better mixture either of hardwoods or hardwoods and softwoods the period of maximum yield may be con-

siderably increased. The volume in cubic feet for fully-stocked stands of a given age and site varies considerably with the proportion of mixture.

11. The principal products supplied by these forests are lumber, chemical- and pulp-wood, fuel-wood, maple syrup and sugar. To a lesser extent natural birch oil is produced. Chemical- and pulp-wood products produce such important articles as alcohol, drugs for the pharmacist, paper, and other products.

12. Stands of seedlings or seedling-sprout origin are necessary to produce high-quality wood. The beech-birch-maple type produces thrifty and vigorous sprouts only when cut while young. At times basswood and wild black cherry produce from large stumps sprouts that grow to tree size. Stands of sprout origin break up at an early age.

13. In old-growth forests of this type are to be found dense stands of seedling trees, often numbering 100,000 to the acre, that are ready to shoot up promptly after the mature trees have been cut. In one instance more than 800,000 small trees were present per acre. In clear-cutting operations the small trees or seedlings are often cut or broken off near the ground. These small trees send up sprouts almost immediately and form dense natural even-aged stands.

14. The beech-birch-maple type employs three important methods of reproduction. In order of their relative importance they are: seeding, sprouting, and root-suckering. Maple and birch seed freely and sprout vigorously. The beech seeds less frequently and sprouts less vigorously, a compensating factor being its production of large numbers of vigorous root-suckers. Associated species—wild black cherry, white ash, and basswood—also seed frequently, producing large crops of viable seed.

15. Selective cutting of the best trees like that practiced in the past, and clear-cutting of large areas, should be discouraged. Inferior quality stands follow both practices.

With care in lumbering, beech-birch-maple stands will maintain their quality in reproduction, and may even show a gradual improvement.

The best trees in this type are fast growers; hence, they assume a commanding position in the new stand.

Certain conditions may require a modified system of clear-cutting, for clear-cutting lends itself best to even-aged stands.

Selection forestry, or some modification of it, is admirably adapted to the handling of the beech-birch-maple type. Careful removal of selected trees makes it possible to control the composition of succeeding stands, and goes far to guarantee a sustained yield of increasing quality.

TIGHT BINDING

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THE CLEARFIELD
State Forest Tree Nursery

By

William F. Dague
District Forester, Moshannon State Forest
Clearfield, Pennsylvania

BULLETIN 47

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS

Charles E. Dorworth, *Secretary*
Joseph S. Illick, *Deputy Secretary and State Forester*

Harrisburg, Pennsylvania
1928

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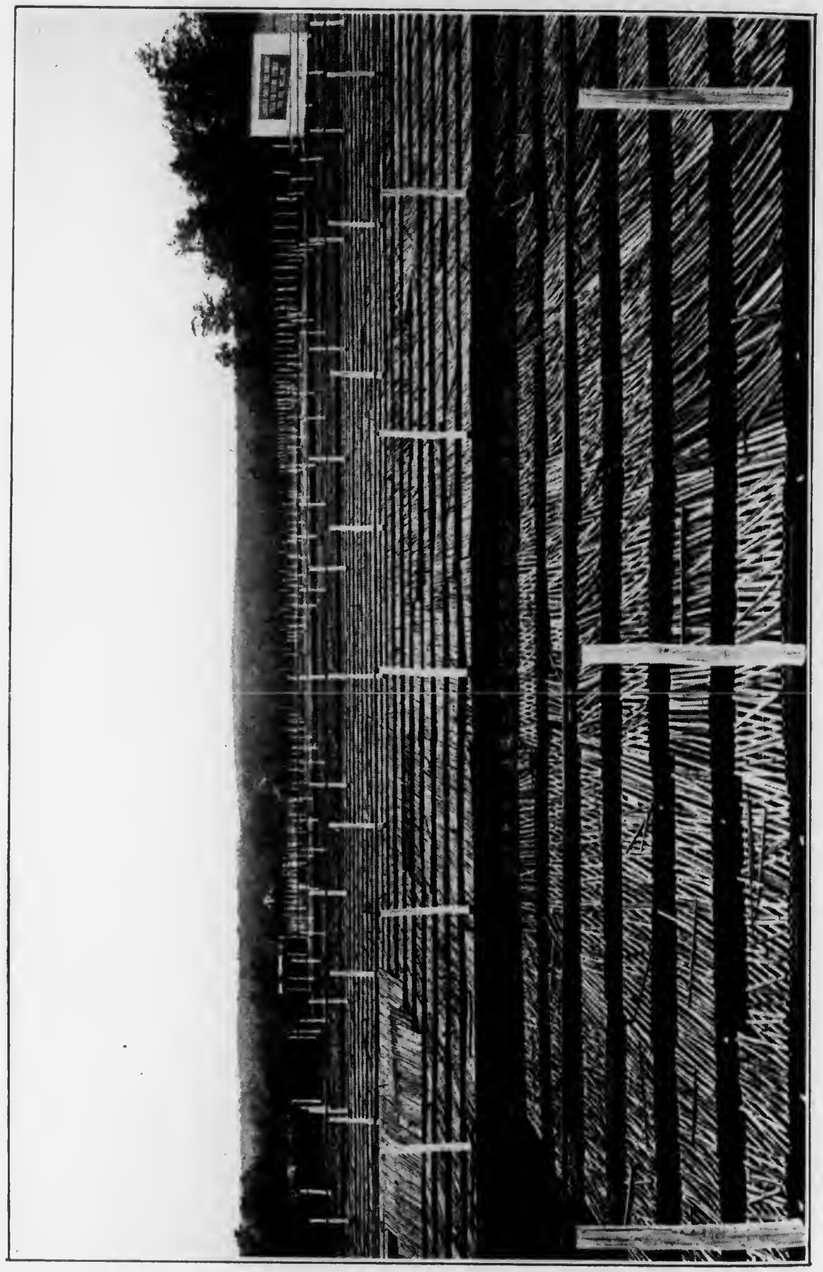

General view of Clearfield Forest Tree Nursery

THE CLEARFIELD
State Forest Tree Nursery

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FOREWORD

On June 13, 1898 Pennsylvania purchased her first land for State forest purposes. Since then there have been purchased a total of 1,186,000 acres. A survey of the land purchased showed that large areas were in urgent need of reforestation at the time of their acquisition. To restore these cut-over and burned-over areas to production necessitated the planting of trees. Not having any available trees for planting, it became necessary to grow them in forest tree nurseries.

The first forest tree nursery operated by the State was established at Mont Alto in Franklin County in 1901. With the enlargement of the State forests the demand for forest tree planting stock grew rapidly. This necessitated a corresponding increase in nursery production. To meet this demand other nurseries had to be established. Among these additional nurseries was the Clearfield Forest Tree Nursery, started in a mountain pasture in Clearfield County in 1911. From a small beginning this forest tree nursery has grown into the largest now operated by the Pennsylvania Department of Forests and Waters. The Clearfield nursery covers about 20 acres, and has an annual output of approximately eight million trees. Since its establishment about thirty-seven million seedlings and transplants have been shipped from it. These trees have helped in a substantial way to bring back to production thousands of acres of State-owned and privately-owned forest land in all parts of the Commonwealth.

Since its establishment, the Clearfield Nursery has been in charge of William F. Dague, a graduate of the Pennsylvania State Forest Scholl in the class of 1908. In this bulletin District Forester Dague gives the history, describes the conditions, outlines the operations, and discusses the problems of the Clearfield Forest Tree Nursery in an interesting and accurate way. I recommend this bulletin most heartily to those interested in the growing of forest tree seedlings and transplants.

JOSEPH S. ILLICK,
State Forester of Pennsylvania

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THE CLEARFIELD STATE FOREST TREE NURSERY

THE Clearfield Forest Tree Nursery, located on the Penfield Pike, nine miles northwest of Clearfield, in the Moshannon State Forest, is the largest forest tree nursery in Pennsylvania. At present (1928) it contains 20 acres of forest tree seedlings and transplants. Its annual production, which in recent years has been growing at the rate of nearly a million trees per annum, is now approximately 8,000,000 seedlings. Since this nursery was started in 1911 as a tiny, experimental planting, approximately 37,000,000 trees have been shipped from it. The number of seedlings and transplants now standing in the nursery totals as many more. Thus this nursery has successfully produced nearly 75,000,000 little forest trees. Some of the practices evolved here have everywhere become standard practices in the raising of forest tree seedlings.

Yet this nursery, which has been so signally successful, started with failure. Its creation was due to the Hon. S. B. Elliott, who was a member of both the Pennsylvania Legislature and the old State Forest Reservation Commission. He was an enthusiastic believer in forest tree planting, even in the days when very few people had any faith in such a practice. The region in which the Clearfield State Forest Tree Nursery is located was then sadly in need of replanting. Destructive lumbering had entirely wiped out the magnificent stands of pine and hemlock timber that originally covered the entire district. This timber had been replaced largely by scrub or other inferior growths of trees. Mr. Elliott's thought was to grow little forest trees right on the spot and plant them in the surrounding forest area.

MOUNTAIN PASTURE SELECTED FOR SITE

The site selected was a plot that was part of an old clearing made in the lumbering days and later used as a mountain pasture. There were many old stumps on the area and quite a sprout growth. The land was impoverished and in poor condition. During the preceding year, 1910, a forest ranger who lived nearby had made a rough potato patch here. He had removed the largest of the stones and given the patch some cultivation. Here were prepared 30 seed-beds, each 4 x 12 feet in size, and making a total area of one-tenth of an acre.

Thrifty seedling beds in the Clearfield Forest Tree Nursery

A block of spruce transplants

The seed sown was secured from the Mont Alto State Forest Tree Nursery, being stock that remained after the planting of the seedbeds there. It was received at the Clearfield nursery too late in the season to make a successful planting. The weather had become very dry and there was no water available for sprinkling. Nevertheless, an effort was made to start a nursery. Germination was poor, and the planting was practically a failure. Mr. Elliott, however, insisted that another trial be made. The following spring the nursery was doubled in size, seed was secured early, and no effort was spared to make the attempt a success.

OVERHEAD IRRIGATION INSTALLED

That it was a success is shown by the fact that in 1914, just two years later, the nursery was increased in size to a full acre. Also, an overhead irrigation plant—the first sprinkling system used in the State in a forest tree nursery—was installed that same year.

Over-head sprinkling system in Clearfield Forest Tree Nursery

Two years later the nursery was expanded to four acres, and the sprinkling system enlarged to cover the entire area. In 1917 additional clearings were made, on the opposite side of the road, and in 1918 a half acre was added for the raising of ornamentals. Steadily the size of this nursery was increased, until now it occupies the 20 acres mentioned, all of which are under irrigation. When this entire area is fully utilized, the annual capacity of the nursery will probably be fully 10,000,000 forest trees.

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INTENTIONAL SECOND EXPOSURE

CLEARFIELD NURSERY HAS PECULIAR CONDITIONS

The Clearfield State Forest Tree Nursery, like every other nursery, has certain conditions peculiar to itself, some of which are favorable, while some are unfavorable. One of the rather unusual conditions at this nursery is the plague of deer. These animals have now become so numerous in this region that it is wholly impossible to raise anything that is not protected by deer-proof fences. This situation affects the forest as well as the nursery. This immediate neighborhood would still be benefitted immensely by replanting. Yet it is utterly futile to make such plantings. The deer eat the little forest trees almost as soon as these are set out. For this and other reasons, practically all the trees grown at the Clearfield nursery are now shipped away, for planting in other State forests, or for use by private planters. The early plantings near the Clearfield nursery, made in 1913 and 1914 with the first seedlings produced there, before deer were so numerous, have grown thriftily. The red pine plantation then made opposite the ranger's house has now reached a height of 20 to 25 feet and is a beautiful sight. It is proof conclusive of the value of forest tree planting.

GOOD WATER IS ABUNDANT

One of the favorable conditions at this nursery is the good supply of water that has been made available through the utilization of an old sawmill dam nearby, and the installation of a pumping outfit and springler lines. Another favorable point is the fine shipping facilities. Clearfield is nine miles distant and Penfield seven. Four

Trees are transported by truck from the Clearfield nursery to the shipping points at Clearfield and Penfield

different lines of railroads enter these two towns. They are the Pennsylvania, the New York Central, the Buffalo, Rochester and Pittsburgh, and the Buffalo and Susquehanna. Trees for shipment are hauled in motor trucks to these two distributing points. Such unusual shipping facilities make is possible for purchasers of trees to get their plants at very small expense for transportation.

The Clearfield State Forest Tree Nursery is situated in the Allegheny Plateau region, on land that is nearly level yet slopes slightly toward the north. Its elevation is about 2200 feet above sea level. The country for miles around is uninhabited forest land, occupied by second-growth stands of hardwoods and white pines. The greater part of the 20 acres that comprises this nursery was cleared, prepared, and seeded for the first time, in the making of this nursery.

SOIL CONDITIONS ARE IDEAL

The soil here is DeKalb stony-sandy loam. The surface soil consists of a light-gray loamy sand, three to four inches deep, which rests upon a yellowish sandy loam that extends to a depth of eight inches. The subsoil is a heavy yellow sandy loam, frequently with a noticeable content of silt. Bedrock is encountered at a depth of 40 to 60 inches. When the land was cleared, varying quantities of sandstone and conglomerate fragments were found strewn throughout the surface layers. The soil is an ideal one for the raising of coniferous seedlings, which do best in a sandy loam. Such land does not bake or heave and is easy of culture.

The climate, too, is favorable, being comparatively uniform. The winters are long and cold. Frequently the temperature falls below 10°F. The mean temperature for the winter is 24.4°F. The summers are pleasant. The mean summer temperature is 68°, while the maximum is 98°.

Rainfall is abundant. The average precipitation is 44 inches per annum. This is well distributed throughout the year, but naturally is heaviest during the summer months. The mean rainfall for July and August is 13.12 inches. The snowfall is heavy, usually covering the beds during the entire winter.

For the raising of seedlings from seed obtained from forest trees of the temperate and frigid zones, the climate is ideal. The growing season is several weeks shorter than is the season in most eastern nurseries. Although this has a tendency to produce smaller trees, the altitude and climate are such that greener healthier and hardier trees can be produced here than are produced in nurseries that have a longer growing season.

HOW THE SOIL IS PREPARED

The first step in preparing this nursery was naturally the clearing of the land. There were many stumps, some of which were large. The smaller ones were pulled out by a tractor. The larger ones were blown out with dynamite. The big stones were collected and carted away. The ground was then plowed deep, and the roots

Pulling stumps from prospective nursery site

gathered and burned. In preparing additions to this nursery, it is the practice to fit the ground for seeding by sowing buckwheat and turning it under at the blossom stage. To enrich the soil still further, a mixture of well-rotted manure and woods soil is spread on the ground. When it is possible, the woods soil is gathered from under a stand of locust trees. Such soil is the best of all woods soil, because it contains nitrogen gathered by the leguminous locust trees. This material is collected in the fall and composted with the manure. Ten tons are applied to the acre. Acid phosphate is also used, and likewise bonemeal. In 1928 commercial supplies of dried peat were secured. This will be used hereafter as a growth accelerator, by mixing it with the surface soil. Peat prevents drying out, lightens heavy soils, holds moisture, and aids soil drainage.

The careful preparation that has always been given to the soil has done much to insure the success of the Clearfield nursery. The ideal seed-bed for forest tree seedlings should be light, loamy soil, well packed with humus and plant food. Such ground absorbs moisture readily, holds it perfectly, drains well, and can be worked easily and promptly after rains. Recent experiments made to determine the effect of rotting organic matter upon the moisture-holding capacity of the soil, show that 100 pounds of sand will hold only 25 pounds of water, 100 pounds of clay will retain 50 pounds of moisture, whereas 100 pounds of humus or decaying organic matter will hold 190 pounds of water. In addition to keeping the soil moist, added humus makes it light and porous, so that roots and sprouts can penetrate it with ease. Humus, of course, largely increases the supply of plant food. It is obvious that the careful treatment of the soil at the Clearfield nursery is the foundation of all the cultural processes.

WEED GROWTH MUST BE SMOTHERED BEFORE PLANTING

In preparing a seed-bed, it is most essential that sod should not be turned under and trees planted in the seed-bed the same season. The buried grass will send up new leaves, which will choke out the forest tree seedlings unless the beds are weeded constantly. The hand-weeding of beds is very costly. By growing a crop like buckwheat or cowpeas, weeds and grass are smothered out. If the buckwheat or peas are themselves turned under before they produce seed, the ground is freed from weeds, put into fine physical condition, and packed with plant food. In preparing a plot for seeding, it is sometimes possible to turn under three green crops in a season. This material will be well rotted by spring, and will improve the texture of the soil greatly. Coarse, unrotted manure should never be applied to the beds immediately before seeding. It is sure to cause trouble in the working of the beds, as well as the loss of plants in dry weather.

CULTIVATION MUST BE CONSTANT

Indeed, the cultivation of the soil in preparing a seed-bed should be done with meticulous care. At the Clearfield nursery this cultivation begins with the removal of the loose stones. The ground is then plowed as deep as the plow point can be made to run. Stones brought to the surface in plowing are picked up. The plowed ground is then worked repeatedly with a spring tooth harrow or a disc harrow, first lengthwise of the furrows, then crosswise, then zigzag, in an effort to level the area. Stones are again hand-picked. A spike tooth harrow is used in an effort to smooth and level the ground, and the soil is further pulverized and smoothed with a cultipacker. This implement is kept going until the soil is as fine as it can be made. Where inequalities in the surface exist, a drag or float is used upside down, in an effort to fill up the low places.

No effort is spared to get the ground for the seed-beds, not only fine and smooth, but also perfectly level. Time spent in preparing

a proper seed-bed is easily saved in the subsequent working of those beds. Furthermore, the proper conditioning of the seed-bed may make a difference of many thousands in the prospective stands of tree seedlings.

HOW THE SEED-BEDS ARE LAID OUT

The actual laying out of the beds is done with the same care and exactitude. After the soil is thoroughly prepared, it is the practice at the Clearfield nursery first to stake out the beds. Four feet has been found to be the most convenient width for these, and is the standard width of all seed-beds in the Pennsylvania State forest tree nurseries. This is the maximum width for convenient and easy hand-weeding. Formerly seed-beds were made 4 x 25 feet in size, thus giving a unit area of 100 square feet to the bed. The practice at the Clearfield nursery is now to make the beds four feet wide and as long as the planting space permits. The longest rows there are about 280 feet. The paths between beds are two and a half feet wide. The alleys at the ends of the rows may be of various widths, but should not be less than nine feet wide. There must be sufficient room in these alleys to permit the piling of shades and other materials, and the free passage of motor trucks, teams, carts, etc.

PERMANENT MARKERS SHOULD BE USED

When beds are to be used year after year, the corners should be permanently marked and numbered with iron pins, set just beyond the true corners of the nursery beds, across the end alleys or along the nursery fence, where the pins are out of the way of cultivation. When a line is drawn connecting two of these opposite corner pins, the line marks one side of the nursery bed. Where there are many small beds composing one long row, permanent pins are set in the same way along the other two sides of the nursery, so that when lines are drawn between two opposite pins, they form the end sides of the nursery beds. These permanent markers or stakes save much time when it comes to laying out the beds. Wooden stakes used to mark beds temporarily should be one by two inches and 18 inches long. These are set at the corners of the little beds and left there until the beds have been thrown up and raked smooth. Then they are removed.

After the stakes for the beds are in position, lines are stretched to indicate the exact boundaries of the beds. It is very important that the stakes along a given boundary be exactly in line, in order that the subsequent working of the beds be not impeded. When the lines are in place and drawn taut, the soil from the paths is thrown up on the beds to a depth of three to six inches. In small nurseries

Seedling beds and nursery paths are made in one operation by use of a double-mold-board plow

Nursery beds are raked down in the same fashion as the home garden, preparatory to sowing

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this is done by hand, with sharp-pointed spades; but at the Clearfield nursery the paths are made with a specially designed plow that has a double mold board. End paths are not spaded or plowed up.

THE CONSTRUCTION OF THE SEED-BEDS

The greatest care is now given to the actual construction of the beds. Again the lines are checked, to make certain that everything is right. Then laborers with rakes, working in pairs, one man on each side of the bed, begin to smooth and level the soil. This is carefully pulverized, and all stones and clods are raked to the paths, for subsequent removal in wheelbarrows. The beds are usually raked three to four inches beyond the side lines; but the greatest care is taken to see that the completed beds are exactly four feet wide, and the sides perfectly straight. A stake out of line catches implements and garments, and impedes the workers. An untrue path shunts surface water into, and sometimes through, the planted beds. If there is much slope to the ground, the resulting damage may be serious.

The completed beds at the Clearfield nursery are about four inches higher than the paths. In moist locations, or where the soil is heavy, it may be necessary to make the beds higher still, to insure drainage. The surface of the beds should be perfectly level. If the ground in the nursery slopes, the beds must of course carry the slope of the paths, but the surface of the beds should be perfectly smooth and even. Depressions that have not been filled by the cultipacker and harrow, can now be filled by throwing in well-pulverized soil.

BEDS MUST BE LEVEL OR SLIGHTLY ROUNDED

Beds should never be lower in the middle than they are at the sides. Low bed centers retard drainage and cause "damping-off." In light sandy soils, like that at the Clearfield nursery, the tops of the beds may be level; but on heavy clay soils, the surface should be slightly convex, being one to one-and-a-half inches higher in the center than at the edges. Heavy soils may be improved by mixing sand, charcoal braze, or commercial peat with it, before the beds are raked. The practice of continually adding considerable amounts of humus to the soil, as is done at the Clearfield nursery, will do much to lighten any ground. The degree of care necessary in finishing a bed depends to some extent upon the nature of the seed to be sown. For sowing small seed, such as that of pine, spruce, or larch, very fine smooth beds are desirable, such as a gardener would make for seeding lettuce.

In all seed-bed making the aim is to obtain a thoroughly-worked mellow soil for a depth of about 10 inches. The first cost of a thoroughly prepared bed is only a fraction of a cent more per square foot than is the cost of a poorly-prepared bed. The latter may result in the loss of thousands of seedlings. The loss of even a single thousand will amount to more than the added cost of proper preparation. Furthermore, the expense in succeeding years will be greatly reduced by a thorough preparation when the beds are thrown up. A thin layer of compost or bonemeal may be worked into the soil in this preparation.

THE MENACE OF DAMPING-OFF AND SHEDDING

The so-called "damping-off" diseases attack seedlings of nearly all tree species as soon as they emerge from the ground, or even before. The specific fungi causing this loss are legion. Some are wholly subterranean in their attack, others weaken the plants just at the surface of the soil, while still other forms attack the crowns of the seedlings. They cause the needles of conifers to draw together at the tips and quickly wither. In every planting there are practically always losses due to damping-off, though sometimes such losses are negligible. These fungi, it is safe to say, are the most serious source of loss in forest tree nurseries. Sometimes practically every tree in a promising bed may be killed within two or three days.

Too much heat and moisture cause the activity of these fungi. It is readily apparent, therefore, how important proper drainage and ventilation are in the production of forest tree seedlings. Hence the need to work the soil so carefully, until it is perfectly porous and loose and shaped so that it facilitates drainage.

ACIDITY IN THE SEED-BED PREVENTS GREAT LOSSES

As the forest floor, in a state of nature, is always damp and moist, one may well wonder how any seedlings in the woodlands ever escape the damping-off process. The forest floor is acid, as well as moist, the acidity resulting from the decay of vegetable matter. It has been found that artificially-induced acidity in a seed-bed also prevents serious loss from damping-off. Hence, when there is likely to be much loss from this cause, treatment of the soil with aluminum sulphate, dilute sulphuric acid, formaldehyde, or other similar chemicals, may prevent or limit damage from this cause.

These chemicals must be used in the correct proportions, however, yet it is not possible to lay down any rule for determining those proportions. Different soils differ in native acidity, and the acid added must be varied with those differences. In other words, the nurseryman simply supplements the acid already in the bed.

If what he adds is too weak, his solution will be ineffective; if it is too strong, it may kill the little trees. Each nurseryman must determine, through experiment, the proper proportions for his particular soil. When damping-off is noticed, prompt spraying with Bordeaux mixture may prevent serious loss.

The removal of shades from the beds during and immediately after wet weather, thus drying out the beds quickly and reducing the soil moisture, is also helpful. But as soon as the soil on the surface of the beds seems dry, the shades must be replaced, or loss will result from the intensity of the direct sunlight on the tender seedlings. When these are six weeks old they are usually woody enough to resist damping-off fungi. "Shedding" is a late summer disease.

SHEDDING USUALLY ATTACKS CONIFERS

Another difficulty that little trees encounter, in late August or September of their first year, is called "shedding." It appears earlier in the season during the second and third years. This disease commonly attacks conifers, particularly white pines. It is worst in densely-stocked beds. It may destroy all seedlings in considerable areas. The trouble is most serious in the middle of the beds. The leaves turn yellow and wither. This disease resembles sun-scorch, but differs from it in that shedding attacks the tree from the ground upward, while sun-scorch begins at the tips and works downward as the hot sun scorches the upper leaves of the tree. Anything that can be done in the making of the seed-beds that will prevent or lessen the attacks of damping-off fungi or the shedding disease, is very evidently time well spent.

One of the practices in bed making at the Clearfield nursery, which is standard in all the State forest tree nurseries, is to use a seeding frame in sowing the beds. This is a frame of timber, 4 x 12 feet in size, made of two by one inch boards set on edge, with cross strips for handles. It is set exactly on the side lines of the bed, and the seeding is done within the frame. This insures the seeding of a strip exactly four feet wide. As fast as sections are seeded, the frame is moved along the row. To give the center plants more light and space and thus provide better ventilation for the interior of the beds, one and sometimes two timber strips, each six inches wide, are run lengthwise of the frame in the center. No seed can be sown in the spaces occupied by these middle timber strips. Thus narrow longitudinal unseeded lanes are provided in the stands of seedlings. In addition to helping to prevent damping-off and shedding, these open strips allow cultivation along the centers of the beds.

HOW THE SEED-BEDS ARE PLANTED

Seeding must be done as exactly as possible. The seed for each bed is weighed out and sowed by hand. It is scattered very thinly and the bed gone over twice. This usually gives very even distribution. To guard against too dense stands, which tend to produce damping-off, and to secure sturdier seedlings by giving each plant more room for growth, the amount of seed sown is kept to the minimum. At the Clearfield nursery the quantities have been reduced so that at present only eight ounces of red pine seed are used to sow 100 square feet. Pitch pine, Scotch pine, and Norway spruce are seeded at the same rate. Seven ounces of white spruce seed are used. Japanese larch is seeded with 10 ounces to 100 square feet, and 12 ounces of white pine seed are used.

Germination tests are made before seeding, just as a farmer tests seed corn, and detailed records are kept as to the percentage of germination, sources of seed, its price, condition, etc. These records, coupled with the records of the stands secured from the seed, should in time be most valuable in pointing to the sources of the best seed supplies.

BIG ROLLER BEST FOR FIRMING BEDS

When the seeds have been scattered on the beds, they are pressed into the soil and the beds firmed by the use of a large roller, four feet in diameter. A large roller is used because it has been found that a small roller pushes the seed before it, and so produces uneven stands of seedlings. In small nurseries seed-beds can be firmed with a pressing board, $4\frac{1}{2}$ x $2\frac{1}{2}$ feet in size, which is manipulated by two men, one on either side of the bed, to move the board and step on it. Where heavy ground must be used for seed-beds, it may be desirable to have a roller with a slightly concave surface, so as to produce a rounded bed to facilitate drainage.

When the seed has been thus pressed firmly into the soil, it must be promptly covered. Seed should be buried to the depth of one or two times the length of its greatest dimension. With small seed, like that of some of the pines, which must be covered very lightly, it is no easy task to apply the covering evenly and to a given depth. At the Clearfield nursery this is done with an improved lime spreader. A sifting box has also been used. This is carried by two men, one on either side of the row. Such a box is 2 x 3 feet and 10 inches deep, with handles at either end, and a wire-mesh bottom. Well-rotted compost or woods soil is best for this purpose, although charcoal braze has given good results. Sand has been used successfully on Scotch, pitch, and other "hard" pines. It can be used on white pine in fall seeding, but is too hot for most small seed. The

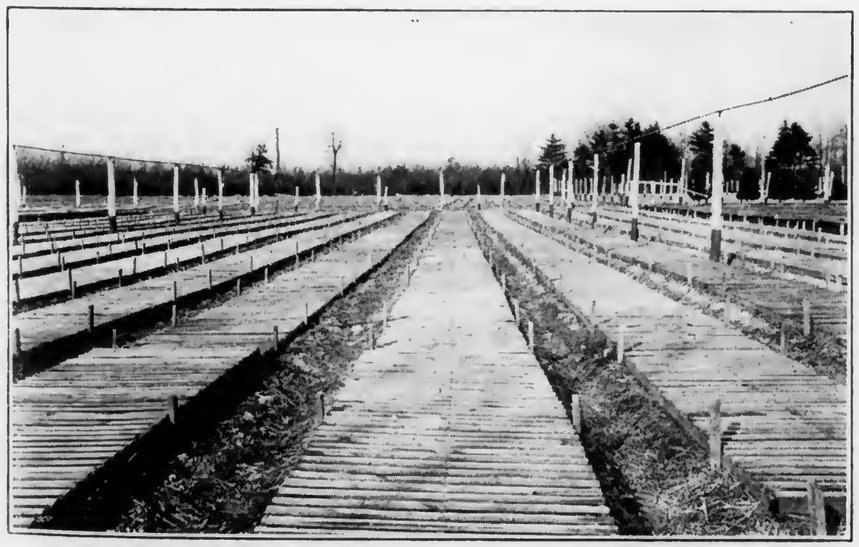
Sowing seed beds with the aid of a planting-frame

Freshly sown seed is pressed into the soil by means of a large heavy roller

chief advantage in the use of sand lies in its freedom from weed seed and the spores of fungi. However, this is to be remembered: nature, through millions of years, evolved the very best methods. At the Clearfield nursery an effort is made to duplicate those methods so far as possible. Hence woods soil or some similar material, such as well-rotted compost, is preferred for covering seed. For spreading this material, wire with three meshes to the inch is suitable for use in a hand sifter. Sand should be applied through a wire with four meshes to the inch.

THE BEDS ARE MULCHED WITH STRAW

After the seed is covered, the beds are mulched with about an inch of straw that is free from weed seed. Leaves, bracken fern, or pine needles can be used if available. At the Clearfield nursery a specially-constructed cart is employed for mulching. Its wide-set wheels straddle the bed. The back of the cart is open. Two men, one on either side of the bed, draw the cart by its long cross-handle, and a worker back of the cart pulls the straw out behind as the cart moves slowly along. When the mulch has been spread, cross-strips and shades are laid on it to hold it in place. The purpose of this mulch is, of course, to insure both good shade, moisture conditions, and to keep the soil loose and prevent it from baking, so the seed can sprout. If the season is dry, it is advisable to sprinkle the beds either before seeding or after applying the mulch.



Newly sown nursery beds mulched with straw held in place by wooden screens. When the seed germinate the straw is removed and the screens raised on the posts

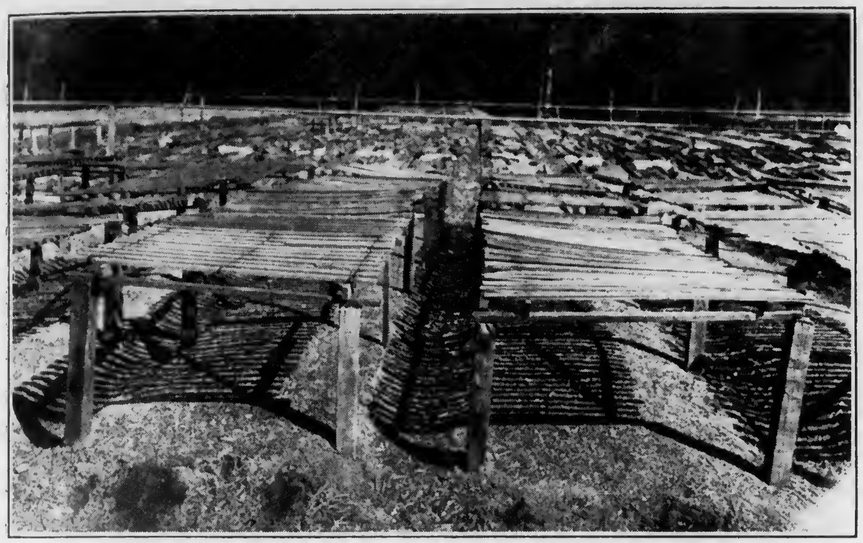
Careful watch is kept of the freshly-seeded beds; and when approximately half of the seed has begun to send up sprouts, the mulch is removed. This is carefully forked off and gathered. When germination is slow and irregular, extreme care must be exercised. The mulch must be allowed to remain as long as possible, yet removed before the quickest-sprouting plants are weakened. Daily examinations of the beds are made. Severe injury may be done to the stand at this time if extreme care is not used. Mulch should preferably be removed on cool or cloudy days, or in the early morning or late afternoon. So far as possible, conditions of shade found in the forest should be maintained. The beds must neither be allowed to dry out nor be soaked with water at this time. When sprinkling is necessary, it should be done in the form of light showers.

SEEDING RECORDS ARE KEPT

In connection with this matter of germination, the seeding records kept at the Clearfield nursery should eventually prove very valuable. They will indicate the sources of the quickest-sprouting most vigorous seed. In time this should lead to the selection of special groups of trees to be set apart for the distinct purpose of supplying superior seed. Indeed, the location of one or two such stands of trees has already been noted.

HANDLING THE BEDS AFTER GERMINATION OCCURS

When the little seedlings have at last emerged and stand clear above the seed-bed, every effort must be made to duplicate natural conditions of growth. Shade is a first requisite. At the Clearfield nursery, as at all other Pennsylvania State forest tree nurseries, an adequate supply of shades is on hand to cover all beds. These shades are made on the grounds, of lumber especially sawed for the purpose. Laths $1\frac{1}{2} \times \frac{3}{8}$ inches and four feet long are nailed to 12-foot strips that are $2\frac{1}{2} \times 1$ inch. The laths are spaced about their own width apart—$1\frac{1}{2}$ inches—so that when it is desirable loose laths may be laid between them. Thus conditions of half-shade or full-shade can be had at will. These shades are supported by frames made by driving two stakes, $1 \times 1\frac{1}{2} \times 1\frac{1}{2}$ inches, into the ground on opposite sides of the beds, with cross-pieces laid on the stakes. The stakes are 2 feet long, and are driven down a foot. The cross-pieces are of one-inch material. The stakes must be very carefully driven, in line, so as not to interfere with cultural operations. When these stakes are properly set, the shades are approximately 12 inches above the beds. At the Clearfield nursery the beds run east and west. It is



Young seedlings require shade. Artificial shade is provided by means of lath screens set on posts over the nursery beds

One-year old seedlings are protected with a covering of straw during their first winter

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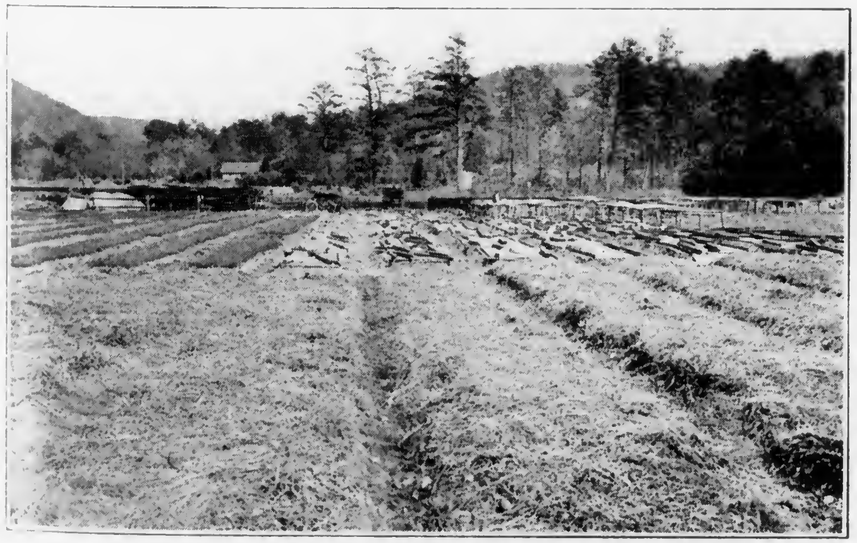

One-year old seedlings are protected with a covering of straw during their first winter

INTENTIONAL SECOND EXPOSURE

always desirable to run the beds this way when it is possible, as the direct rays of the early morning and late afternoon sun will then strike the fewest possible seedlings.

FOREST TREE SEEDLINGS NEED SHADE

Half-shade is sufficient for most coniferous seedlings. Spruce and hemlock do best in full-shade. Practically all forest tree seedlings prefer some shade. The laths in the screens are adjusted to the requirements of the seedlings. Weeding must be done when necessary. This is of course hand-weeding. The worker props the screen up on one side and is able to weed half the width of the bed with ease.

If birds become troublesome by picking the seed caps from the seedlings, boys can be employed for a week or ten days to scare the birds away. After that period the danger is past. In small nurseries wire screens can be set over the beds.

During the summer months beds are watered whenever three days of sunshine have passed without a shower. Waterings should be in the late afternoon or at night or early morning, but never during the hot part of the day. The overhead irrigation system at the Clearfield nursery makes it possible to wet every inch of the seed-beds simultaneously.

REMOVING SHADES HARDENS TREES FOR WINTER

Late in September the shades are removed from the beds, so that the trees are exposed to full sunlight and frost. This checks further growth and hardens the wood in preparation for winter.

After the ground has frozen several times, and the forest leaves have fallen, seedling beds should be mulched with straw, leaves, bracken fern, or pine needles. Here again the nurseryman is merely duplicating nature's process. She covers her seedlings with fallen leaves.

At the Clearfield nursery straw is used almost exclusively for mulching. This has been found to be the most practicable material to use. It is easy to secure, it can be used repeatedly, it occupies relatively little space (baled straw is purchased), and it is easily handled. Yet so much straw is required to cover 20 acres that at the Clearfield nursery a large storage shed is practically filled with straw. In spring the mulching material must be promptly removed, lest the young trees mold or mildew.

The care of the two- and three-year-old seedlings at the Clearfield nursery is limited to weeding and watering as is necessary, with some cultivation. Very little or no hoeing is needed, as the paths are cultivated with a horse-drawn cultivator with the blades set close together, or with a gasoline-driven cultivator operated by one man.

HOW SEEDLINGS ARE TRANSPLANTED

The setting of seedlings into transplant beds is done by the use of transplant boards. Three types of such boards are in use at the Clearfield nursery. One, with coiled springs to hold the plants, was invented by Mr. T. O. Bietsch of the Pennsylvania Department of Forests and Waters. These boards are six to eight feet long, and are so made that they hold the seedlings upright in little slots. One board will hold 30 to 60 seedlings. Seedlings are brought from the beds by one set of workers, while another inserts the seedlings in the boards, which are then passed to a third set who do the actual planting. Trenches are dug with short, square-ended shovels, which are thrust straight down along the edge of a trenching board, in order to make the trench perfectly straight. When a trench is ready, a transplant board filled with seedlings is set upright in it, and earth is drawn over the roots of the plants and tamped firm. The trees are then released from the board, and the board drawn out of the trench. The planted section is now filled level with earth, and another board of trees set in. Thus transplanting can be carried on rapidly and cheaply.

Great care is exercised to see that wind and sun do not dry out the seedlings during the handling. The roots of the little forest plants are kept moist at all times, the main supply standing in tubs that contain some water. Cultivation of transplants is done as needed, and a light covering of straw is applied for the first winter. Older transplants need relatively little care.

DIGGING THE SEEDLINGS

To transplant thousands of little seedlings, each but a few inches high, involves a great amount of labor; but the work entailed in transplanting is trifling in comparison with the task of shipping the millions of trees annually sent out from the Clearfield nursery. Originally trees for shipment were lifted by workers with spading forks. An instrument is now in use, however, that does away with all this labor. This tree lifter consists of a steel blade three-eighths of an inch thick, 12 inches wide, and four feet long, attached to a metal frame. This lifter is drawn along the bed, with the blade 10 inches under the surface, by a cable pulled by a tractor. The cable passes through a pulley fastened to a tree or heavy post at the far end of the bed. The tractor moves one way while the lifter goes the other. A heavy team of horses can also be used. As the lifter moves along, it heaves up all the seedlings in the bed, lifting them bodily and loosening them in the earth. It is then a simple matter for the workers to gather them, shake the earth from the roots, and pack

them in boxes for hauling to the storage pit. A commercial shrub digger, with a U-shaped blade, is used to lift transplants and larger trees. This implement not only digs trees cheaply, but also lifts the entire root systems. It gives much more saisfactory results than can be obtained by the use of a spade or fork.

FIVE THOUSAND CUBIC FEET OF TINY TREES

The storage pit or cellar mentioned is a portion of the basement of the packing shed, enclosed with stone walls, and having an earthen floor. It is 36 x 20 feet and seven feet high. In small nurseries, trees can be packed in the open, as they are lifted from the beds. But where millions of seedlings are to be shipped, field packing is out of the question. Also, the work must be carried on during every working minute, regardless of the weather. Planters must receive their shipments of little trees at the earliest possible moment in spring. The moment the frost is out of the ground, therefore, and the soil sufficiently dry for handling, the tree lifters are started, and a steady stream of trees moves to the packing house. At the same time, shipping goes on. But the lifting of the trees progresses so much more rapidly than the shipping that the storage cellar soon begins to fill. It is no unusual thing to have this cellar, which contains more than 5,000 cubic feet, entirely filled with tiny seedlings. Sometimes the seedlings are piled four boxes high. As the capacity of the nursery grows, it will be necessary to enclose additional storage space.

HOW EIGHT MILLION TREES ARE SHIPPED

In the spring of the year the nursery force of 40 or more men is enlarged to fully 60, and nursery and packing house present a busy picture. For an entire month or more before shipments begin, a force of stenographers has been busy making out shipping tags and bills of lading. Four copies of each shipping order are made—the original and three carbon copies. One is kept at the forester's office, one is sent to the district forester in whose district the planting is made, one goes to the Department headquarters at Harrisburg, and one is for the recipient of the trees. These shipping orders, with addressed shipping tags, and the necessary wooden labels to mark the various species of trees that make up the order, are put together in units. Thus everything needed for one shipment is clipped together. A packer makes up an order, labeling each bundle of seedlings with the proper labels, packing the roots in moist sphagnum moss, then bundling the shipment in an appropriate container, and attaching necessary shipping tags to it.

Lifting seedlings by means of the Clearfield tree lifting machine. A broad blade severs the soil beneath the roots

Grading and counting seedlings in the packing house

them in boxes for hauling to the storage pit. A commercial shrub digger, with a U-shaped blade, is used to lift transplants and larger trees. This implement not only digs trees cheaply, but also lifts the entire root systems. It gives much more saisfactory results than can be obtained by the use of a spade or fork.

FIVE THOUSAND CUBIC FEET OF TINY TREES

The storage pit or cellar mentioned is a portion of the basement of the packing shed, enclosed with stone walls, and having an earthen floor. It is 36 x 20 feet and seven feet high. In small nurseries, trees can be packed in the open, as they are lifted from the beds. But where millions of seedlings are to be shipped, field packing is out of the question. Also, the work must be carried on during every working minute, regardless of the weather. Planters must receive their shipments of little trees at the earliest possible moment in spring. The moment the frost is out of the ground, therefore, and the soil sufficiently dry for handling, the tree lifters are started, and a steady stream of trees moves to the packing house. At the same time, shipping goes on. But the lifting of the trees progresses so much more rapidly than the shipping that the storage cellar soon begins to fill. It is no unusual thing to have this cellar, which contains more than 5,000 cubic feet, entirely filled with tiny seedlings. Sometimes the seedlings are piled four boxes high. As the capacity of the nursery grows, it will be necessary to enclose additional storage space.

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Grading and counting seedlings in the packing house

INTENTIONAL SECOND EXPOSURE

SMALL SHIPMENTS GO BY PARCEL POST

Small shipments of trees go by parcel post. Some of these may merely be wrapped in heavy paper. Collapsible mailing tubes of cardboard and waterproof paper stand ready, that will contain 100 to 200 trees each. Larger shipments go into corrugated pasteboard containers. The proper formal labels were pasted on these months previously. They come in knockdown form, and are opened and stapled. It has been found that containers glued together often come apart in shipment, the moisture from the moss loosening the glue. The largest shipments go into wooden crates. Some are made of veneering, and the largest of all are of heavy slat material. These large shipments go by express.

CLEVER DEVICES SAVE TIME IN PACKING

All trees have their roots packed in moist sphagnum moss and are wrapped in waterproof paper. This paper is secured in rolls, which are mounted on cutting frames, similar to those used in grocery stores or butcher shops. Thus strips of paper, of any desired lengths, can be cut off quickly and smoothly. Originally this waterproof paper came in sheets and was cut by hand with shears. The new device is a tremendous time saver.

In much the same way strings for tying bundles of trees are cut most expeditously. Hempen twine, with 70 or more separate ends twisted loosely in a long roll like a rope, is drawn over a sharp scythe blade fixed in a frame. Thus with one motion of the hands a worker cuts 70 or more lengths of twine. The strings are cut to a standard length suited to tying the bundles of fifty seedlings each.

The sphagnum moss for packing the trees is gathered close at hand in the Moshannon State Forest by the regular force of workers in the fall. They pull it up by the handsful and stuff it into containers, which are taken to the moss house. This is a structure built something like a corn crib, and about 10 x 16 feet in size. The workers entirely fill this with moss. Fifty tons of sphagnum are used every year. The moss beds renew themselves, so that the forest provides a continuous supply.

THE KINDS OF TREES PRODUCED AT CLEARFIELD

Among the millions of trees at the Clearfield nursery the following species are being produced:

Hemlock—Tsuga canadensis
Douglas fir—Pseudotsuga taxifolia
Scotch pine—Pinus sylvestris
Western yellow pine—Pinus ponderosa
Norway spruce—Picea abies
White spruce—Picea canadensis
White pine—Pinus Strobus
Red pine—Pinus resinosa
Pitch pine—Pinus rigida
Englemann spruce—Picea Englemannii
Colorado blue spruce—Picea pungens
Balsam fir—Abies balsamea
Japanese larch—Larix leptoleptis
European larch—Larix decidua
Arbor Vitae—Thuja occidentalis
Jack pine—Pinus Banksiana
Austrian pine—Pinus austriaca
Black walnut—Juglans nigra
Shell-bark hickory—Carya ovata

KEEPING EXPENSES DOWN

Most of the 37,000,000 seedlings that have already been shipped from the Clearfield nursery were produced at a cost of less than $1.00 a thousand. This is particularly true of those raised prior to 1919. From that time forward, when the World War advanced prices so enormously, the cost of producing trees was several times as great as it was before 1918. The increasing use of labor-saving devices, however, has steadily cut down this cost in recent years, until at present trees are being produced at a cost of not more than $2.00 a thousand. That is the price at which they are now sold to private planters, according to an enactment of the 1927 Legislature. Wherever it is possible, machinery is being used to supplant manual labor, and the price of production is steadily falling. Large production is a help in reducing costs.

Packing boxes and other wooden necessities that can be made at the nursery are secured at the bare cost of materials and labor. Lumber is bought at the mill, hauled to the nursery, and sawed with cut-off saw and tractor. At seasons when the field force is not employed in caring for the little trees, the men are shifted to such work as making boxes, shades, cement work, and the like.

THE NURSERY FORCE MAKES EVERYTHING

In fact, practically everything on the place is made by the nursery force. The irrigation plant was constructed by the nursery workmen. This consists of a fine stone pumping house, which is an excellent piece of masonry, and in which is installed a 15-horse-power engine, well mounted on a cement foundation. This is connected with the old mill dam by a large intake pipe, and coupled to a five-inch pipe line, which conveys the water to the nursery, half a mile distant. The overhead pipes there are 50 feet apart, and there is a total of 13,500 feet of piping in the system. This irrigation line as well as the pumping house was made by the nursery force. So was the deer-proof fence that encloses the entire nursery. This is more than seven feet high, and is made of heavy woven wire fencing, strung on very heavy posts that are sunk in concrete to a depth of four feet below the surface of the ground.

THE COST OF A YEAR'S OPERATIONS

The total cost of a year's operations at this very considerable plant is amazingly little. In 1925 it cost the State $10,459.18 to operate this nursery. Now that seedlings are being sold instead of being given away for the bare price of packing, the returns from the sales of trees are lessening the operating cost to the State very sharply. In 1926 the outlay dropped to $8,936.63. In 1927, although a million more trees were shipped than in 1926, the cost to the State was only $6,221.44. The cost of operating the nursery from January 1, 1928, to June 1, was $9,654.21, but the refunds for trees sold totalled $7,931.70, making the actual net cost to the State $1,722.51 for five months. The costs for 1927 itemize as follows:

Supervision	$270.56
Tools and equipment	144.39
Screens and stakes	205.85
Bed making	651.28
Seeds and seedlings	2,787.44
Transplanting	3,851.35
Protection	669.18
Weeding and cultivation	656.70
Winter cover	3.83
Lifting and bunching	889.75
Fertilizing	882.36
Watering	75.75
Transportation	3,839.69
Miscellaneous	10.80
Buildings and grounds	688.63
Total	$15,359.70
Refunds for packing and transportation	9,139.34
Net cost of operations	$6,221.44

TOTAL COST OF THE CLEARFIELD NURSERY

Since this nursery was started in 1911, the State has spent on its development a total of $76,774.54 up to June 1, 1928. This sum represents every penny of net outlay for every sort of purpose. It includes the cost of development, equipment, buildings, replacement and maintenance, and wages paid. This sum, of course, is the amount spent in excess of the sums paid for seedlings by private purchasers. It is only in very recent years that any charge was made for the trees, seedlings being furnished free, and the purchaser paying only a fraction of the cost of packing and shipping. The nursery equipment that has been built up for this $76,000 expended by the State, includes a large storage and tool shed, with some smaller structures of like kind, a big packing house, a moss house, open implement sheds, the pumping station, a large barn, wagon sheds, the deer-proof fence, and many implements, including tractor, roller, harrows, plows, carts, wagons, screens, stakes, and a large number of small implements, such as shovels, picks, axes and scythes.

A GOVERNMENT BUSINESS THAT HAS PAID ITS OWN WAY

The 20 acres of enclosed nursery ground, which was worth probably about $2 to $3 an acre in 1911, is now worth $100 to $200 an acre. It has been developed into one of the finest nursery soils imaginable. The 37,000,000 seedlings in the nursery, even when valued at an extremely low figure, are worth fully $42,000. There are ornamentals worth at least $5,000. The nursery buildings are worth, at the lowest estimate, $10,000. The irrigation system is easily worth $4,000. Screens, stakes, tools, boxes, and other like property are worth in excess of $5,000. These figures are very conservative. The fact is that the present value of the nursery property is practically equal to the entire sum the State has spent on its creation, upbuilding, expansion, and maintenance through all the years of its existence.

During those years the State has, through the operation of this nursery, provided hundreds of thousands of trees for reforesting the State forests, supplied hundreds of private planters with a total of millions of little trees for restoring their woodlands, and so has done much to help along the movement to make the State once more self-sustaining in the matter of a timber supply. With the nursery now worth practically as much as the entire sum that has been expended on it, the State has, in effect, produced the 74,000,000 seedlings grown at the Clearfield nursery at no cost. Altogether the Clearfield State Forest Tree Nursery is an excellent example of the successful government operation of a utility for the people.

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BRUSH BURNING
IN
PENNSYLVANIA

By

George H. Wirt

BULLETIN 48

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS

Charles E. Dorworth, Secretary
Joseph S. Illick, Deputy Secretary and State Forester

HARRISBURG, PA.
1928

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BRUSH BURNING IN PENNSYLVANIA

FROM time immemorial there have been people who at certain seasons of the year, or at irregular times, have had leaves, weeds, grass, brush, or other rubbish to burn. For centuries past, fields and fence-rows have periodically been cleaned by fire. More recently, with the development of the telegraph, the telephone, the railroad, electric power lines, and so forth, numerous kinds of rights of way have to be cleaned, usually by mowing brush. This material must be destroyed and is usually burned. Brush burning, therefore, is a common and wide-spread practice. As so many forest fires come from this practice, it appears worth while to set forth some suggestions as to how to burn without endangering other property that should not be burned.

WHAT WE MUST REMEMBER ABOUT FIRE

There are several fundamental ideas concerning fire which we must keep constantly before us.

1. Fire is a destructive and dangerous force.

2. The forest is valuable property that belongs to some one. The leaves of trees, branches, and other vegetable material usually found on the floor of the forest are very inflammable (burnable) under certain conditions, and will burn even when wet.

3. Fire is not natural to the forest. Except for a few fires set by lightning, fire is produced in the forest only by the action of man.

4. If damage results from man-made fire, it is because of man's failure to restrain within intended bounds the destructive force he turned loose.

5. An individual has a right to have fire on his own property and to burn any part or all of his property, just so long as this fire or burning does not disturb or damage the rights of his neighbor or work harm to the welfare of the community.

WHEN TO BURN BRUSH

WITH these fundamental ideas before us, it is evident that no one should start a fire in the open without a full realization of the danger from flying sparks and unextinguished embers.

There are two periods in the year when out-door fires are most common in Pennsylvania, namely, in spring, between the disappearance of the snow and the start of new vegetation, and in the fall, between harvest time and the coming of the winter snows. Both periods are natural times for clearing away debris.

Spring Burning. At this time of year the farmer is getting ready for plowing and for the planting of new crops. The dead leaves and the grass of the past year sometimes interfere with easy plowing and are hard to turn under. Therefore, the farmer resorts to burning. It is well known that burning destroys weed seed, insects, and diseased plants. On the other hand, there are few fields that do not need additional vegetable matter to increase their fertility, and it is a waste of good material to burn what might be plowed under. Unless the farmer knows that injurious insects or serious plant diseases are present, it is best for him not to burn accumulated plant growth.

However, trees and vines have to be pruned, briars have to be cut, and other debris accumulates that cannot be plowed under. This material should be placed in *small* piles and burned under favorable conditions.

Gardens, too, are cleaned in spring when they are being prepared for planting. House and yard cleaning are also in order. All kinds of rubbish are piled together for burning.

Unfortunately it happens that at the very time this human desire for the disposal of unnecessary and unattractive material is most active, conditions in the forest are most favorable for the starting and spreading of fires. The leaves that fell during the previous autumn, and that were soaked and packed together by the winter snow, are now dried by the sun and blown about by the wind. It is surprising how rapidly tree leaves, dead ferns, and old grass become inflammable after being soaked by melting snows or heavy rain.

In the spring, particularly in March and April, windy weather is the rule, and no one can tell a moment in advance what the wind will do, or from what direction it will blow. Occasionally there is a day when the air seems to be perfectly quiet at a given location, and will apparently remain so for some time. *Beware of a quiet day in spring if you wish to burn anything outdoors.* The starting of even a very small fire at such a time creates rising currents of heated air, which seem sufficient to unbalance the entire atmosphere. In no time a gale is blowing. Sparks are carried great distances. Almost instantly your fire is beyond control. Flaming papers and leaves, especially, are likely

to be carried high into the air and blown far away from where they started.

That persons who burn brush on these deceptive days are caught by these sudden changes in the air is evident from the large number of forest fires caused by brush burners whose fires get out of control. In the 15 years since 1913 the fewest forest fires caused in any one year by brush burning numbered 61 and the greatest number totaled 283. The average number of such fires for the 10 years 1913-22 inclusive, was 112. During the past five years such fires have increased markedly in number, the average number per annum during this period being 191.

On Good Friday, April 6, 1927, there were 159 forest fires burning in Pennsylvania. They burned over a total of 4437 acres of land, doing damage to the extent of $8,468 and costing the Commonwealth $4,054 to extinguish. On Thursday, the day before Good Friday, there were 129 forest fires. They burned over 3,690 acres. The damage done amounted to $11,192 and cost the Commonwealth $2,843.50 for extinction.

The terrible record for these two days is of course exceptional. Nevertheless, the record of forest fires in Pennsylvania during the past 15 years is appalling. During the decade 1913-22 there were 1,123 forest fires caused by brush-burning. The total amount of damage done by these 1,123 fires was $329,339.50. The cost of extinguishing these fires averaged $3,226.91 each year, or more than $32,269 in all. Yet the record for the past five years is even worse than that. Between 1923 and 1927, inclusive, the total number of forest fires due to brush-burning was only a little short of 1,000, the yearly average being 191 such fires. This contrasts with a yearly average of 112 fires for the decade preceding. Also, the damage done was greater on the average during these past five years than it was in the decade preceding. As against an average yearly money loss of $32,933.95 then, there was a loss during the five years averaging $37,056.96. Should this average be maintained for the other half of this second decade, the money loss would total more than $370,560—a third of a million dollars swept away through carelessness. The cost of putting out these fires in this past five years was of course very great. As against an average yearly cost of $3,226.91 for the preceding decade, the cost for the last five years averaged $8,062.30. When we compare the number of fires due to brush-burning with the total number of forest fires, we find that brush-burning fires made up 7.1 per cent of the total during the decade 1913-1922, whereas during the last five years such fires total 7.8 per cent of all forest fires. In short, fires due to carelessness in burning brush are actually increasing relatively instead of decreasing.

In not a single case, doubtless, did the brush burner intend to set fire to the forest. Lack of proper care made it possible for these fires to get out of control.

Considering the fickleness of the wind, the ease with which sparks are carried, and the readiness with which materials on the forest floor will ignite at this time, it is obvious that there is need for extreme care in handling fire in or near woodlands in the springtime. The danger period usually extends from about March 15th to June 1st.

The only safe times for spring brush-burning are when snow is on the ground, when it is raining, immediately after a rain, or at night when there is dew or frost.

Fall. As the crops ripen in autumn there is debris to be disposed of. Those who are far-sighted, endeavor to clean their gardens, fields, orchards, or rights of way before winter comes. They have various kinds of vegetable debris to burn. For the gardener and farmer it would be far better to pile this vegetable debris on a compost heap and let it rot for use as fertilizer in spring. Nevertheless, there is always a certain amount of material which can be disposed of best by burning.

During this time of year, the forest once more is becoming highly inflammable. The leaves fall from the trees and sun and wind soon make them dry as tinder. On clear days in autumn, when the sun's rays are still hot, a single spark will start a fire, and the fall winds will spread the flames rapidly. It is true that at this season there are usually dews and frosts at night, and fogs in the morning. By four in the afternoon, dampness increases, and from then until nine or ten o'clock in the morning there is little danger of fires starting merely from sparks. The real danger hours are from nine in the morning until four in the afternoon. The fall danger period is usually from about September 15th to December 15th.

There is never a time, however, when one can afford to be indifferent to the danger of sparks blowing from an outdoor fire. The safest time for such fires is when there is snow on the ground or when it is raining, because at such times vegetable material on the ground is soaked with water. As long as the materials on the forest floor are damp enough to make it difficult for sparks to ignite them, it is possible to have outdoor fires and to allow the sparks to fall where they will. This condition frequently exists during the night-time. Yet even when the forest floor is damp, a spark may lodge on a sheltered piece of decayed wood and, creating a blaze, dry the surrounding leaves. The feeble flame grows in intensity. The wind dries the material ahead. Soon there develops a rapidly-moving fire. One must prevent such an occurrence. On clear, warm, dry days in both spring and fall the brush burner must be constantly on guard.

Burning material on swampy ground should be done only when the swamp is wet and not during a dry season.

Time of Day. On a damp day, brush burning may be done at any time during the day; but it should be borne in mind that as the sun rises higher in the sky, the temperature increases, clouds may disappear, the moisture on the ground dry out, and the wind arise. A day that begins with dampness and fog may by 10 A. M. become a clear dry day, and as the atmosphere becomes drier, sparks from a fire are more likely to cause trouble. As the sun declines the temperature ordinarily decreases, the wind falls, dampness increases, and there is less danger of sparks starting a new fire. Occasionally in spring, however, there are afternoons and nights when moisture seems to be entirely absent from the atmosphere. Even in the middle of the night or just before dawn, when it is ordinarily very damp, the least spark will start a blaze.

It is evident, therefore, that under ordinary conditions the time at which it is safest to do burning is between 4 P. M. and 6 A. M.

When brush has been burned during the day, operations should stop early enough to permit complete combustion of the burning material so that the embers will be practically dead before nightfall. This will prevent the possibility of danger during the night, after those who have done the burning have gone home, and before they return in the morning. Even when piles of material have burned down, the ashes, embers, and charred pieces should be raked together and thoroughly soaked with water or covered with a heavy layer of ground. Some one should return to the place of burning early on the following morning to make sure everything is safe. When burning is done before the noon meal, some one of the crew should be on guard while the others eat their lunch. In fact *a fire in the open should never be left unguarded.*

During the winter time, damp conditions are most likely to prevail and the temperature is low; yet even in the midst of winter forest fires have started when there was no snow on the ground, and have burned over large areas.

During the summer the leaves are on the trees. Then there is a full canopy over the forest floor. The spring rains and the frequent summer showers are absorbed by the duff of the forest floor and by the soil itself; and the moisture does not evaporate so rapidly. Sun and wind do not have so ready access to the dead vegetable matter. Under such conditions it takes a large amount of heat to start a fire. Sparks have difficulty in getting through green leaves to the forest floor, and are cold before they hit the dead leaves. But when no summer rains fall for periods of two, three, or four weeks, dry conditions develop and when some one becomes careless with his fire, we have summer forest fires.

Time for Brush Mowing. Many rights of way, such as those for telephone lines, telegraph lines, power lines, railroads, roadways, oil pipe lines, and so forth, must be kept free of brush and other vegetable growth. If the brush grows too large it may interfere with wires or with traffic. If much dead material accumulates and a fire should burn over the area, poles might be destroyed or other damage result. The clearing of these rights of way is primarily for the safety of the of the property which is located on them or which passes along them, and secondarily to prevent damage to the property of others.

It is customary to mow such rights of way annually. Necessarily this must be done at a time when the job fits in with other work and when men are available; but whenever possible it is wise to plan far enough ahead so that the mowing of brush may be done in late July, August, or early September. Experience seems to bear out the idea that this is the best time to do such work. After a mowing at this time, new sprouts come up from the roots and use up the plant food stored during the summer. These new sprouts do not harden sufficiently to resist the frosts and consequently are killed by them. The vitality of the roots has been diminished, and there will be fewer and weaker sprouts the next year. After several years of such treatment, the roots from which the mass of sprouts has been coming will be dead and the expense of keeping the right of way clean will be lessened. The mowing of annual plants is much easier than that of woody plants. Frequently such mowing may be done by using a mowing machine instead of the brush hook or scythe, which was necessary at first.

Farmers, too, would do well to plan for the cleaning of fence rows and other places containing brush and briars, during the month of August.

HOW TO DISPOSE OF BRUSH

Brush carried away. As brush is cut, it may be gathered together and hauled to an out-of-the- way place where it may be deposited for natural decay or for burning at some convenient and safe time. This method is frequently followed by farmers and road supervisors. Where a right of way crosses a rocky area on a mountain, the small amount of brush which occurs should be carried away and not burned. If it were burned, sparks might fall among the rocks and set fire to dead vegetable matter, starting a fire that might smolder for days.

Brush carried to edge of clearing. The brush may be carried or raked to the edge of the cleared area and there be left in rows or scattered. Decay is expected to complete the disposal. If there is much material it makes a large windrow or a considerable mat of debris. In open or very rocky country this makes little difference. In forest areas such conditions become a special forest fire hazard.

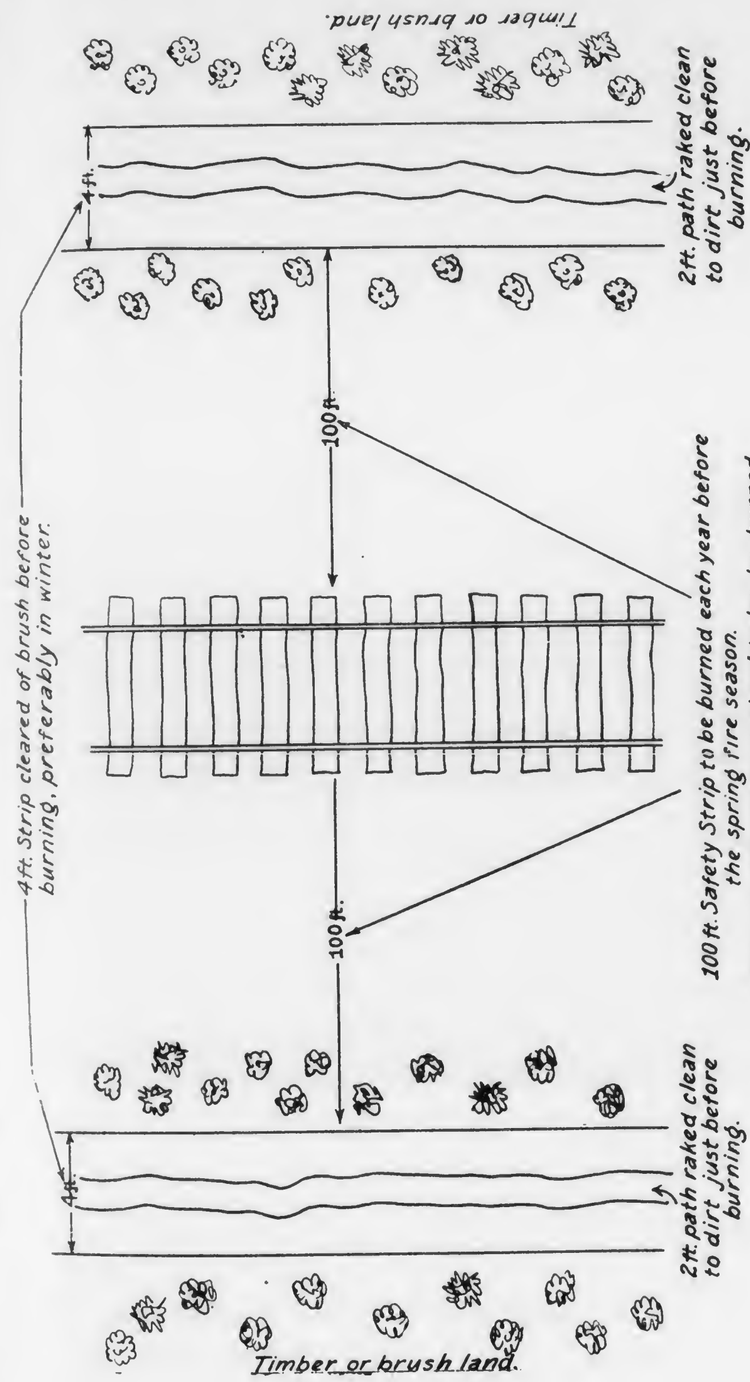

Diagram of Railroad Safety Strip

When such material becomes dry, and some careless individual drops a spark on it or near it, a fire may be started quickly. This may mean an extremely hot fire right at the edge of the cleared area. If the right of way is narrow, the fire can very easily be carried over to the side of it, because of the heat produced by the burning of so much accumulated material. At the same time, the flames may be so hot as to prevent fire fighters from using the cleaned area as a base of attack.

Brush allowed to remain on cleared area. The brush may be cut and allowed to remain where it falls, or raked or piled in a windrow, or placed in piles on the area from which it has been cut . If there is not much of it, or if there is little woody growth, it may be perfectly safe to permit it to decay where it is; but this condition is unusual, and the material is burned under one of the three conditions specified.

Burning entire area of clearing. If the entire area is burned over, the material should be raked toward the midde from both edges, and

CLEAN PATH ON EDGE OF AREA TO BE BURNED

a clean path made on either edge with mineral soil exposed for at least one foot in width. Plowing one or more furrows around the area to be burned may be advisable. Fire may be set along both edges, but it is always preferable to *burn down hill* instead of allowing fire to get started up a hill. It is also advisable to *burn against the wind* instead of having the wind drive the fire. The disadvantage

of burning from both edges are that the sweep of flames may easily get beyond control and that the entire area may be covered with embers from which sparks may be carried to adjoining areas. This method of burning is satisfactory only when the material is dry enough to burn well; and when that is the case, fires will start nearby more easily.

Most of the mistakes of railroad section crews in burning safety strips have come from their starting fires at the edge of the road bed and allowing them to burn up-hill, with the expectation of stopping the fires at the back strips or even without back strips. Fire burns rapidly and fiercely up-hill and is not easily stopped. Consequently, under such methods it is not surprising that instead of a safety strip being burned a whole mountain is burned.

FOREST FIRE WHICH RESULTED FROM CARELESS BRUSH BURNING

So also with farmers and right of way men when they begin burning at the foot of the hill instead of the top, or at the edge toward the wind instead of on the edge away from the wind.

Burning Brush in Windrows. As the mowing or cutting proceeds, the brush and debris may be piled in rows according to the convenience of the workmen. Usually on the ordinary right of way one row piled about the middle is sufficient, but on wide rights of way or larger areas more rows are necessary. The brush row should be as compact as possible, and not too wide nor too high.

In burning the row, the worker should start his fire at the up-hill end, so that the fire may work down-hill, or at the end away from the wind, so that the fire may work against the wind. If the burning

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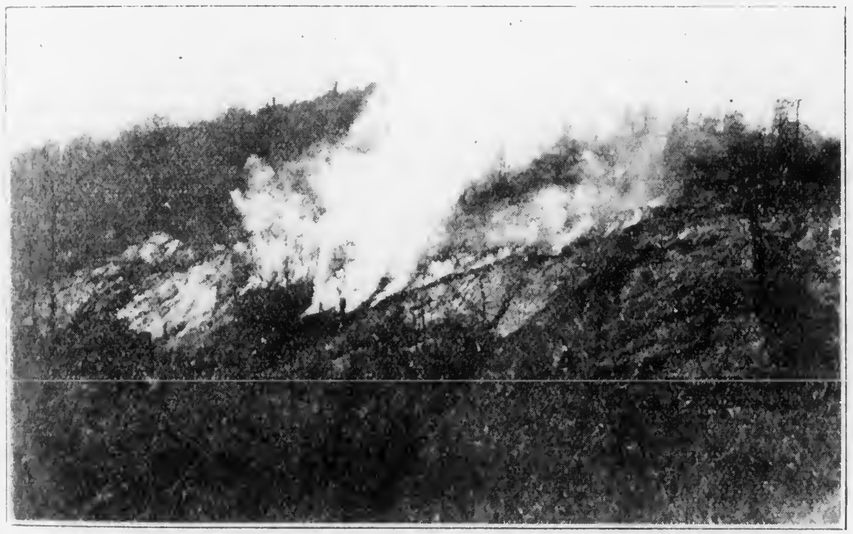


FOREST FIRE WHICH RESULTED FROM CARELESS BRUSH BURNING

So also with farmers and right of way men when they begin burning at the foot of the hill instead of the top, or at the edge toward the wind instead of on the edge away from the wind.

Burning Brush in Windrows. As the mowing or cutting proceeds, the brush and debris may be piled in rows according to the convenience of the workmen. Usually on the ordinary right of way one row piled about the middle is sufficient, but on wide rights of way or larger areas more rows are necessary. The brush row should be as compact as possible, and not too wide nor too high.

In burning the row, the worker should start his fire at the up-hill end so that the fire may work down-hill, or at the end away from the wind, so that the fire may work against the wind. If the burning

INTENTIONAL SECOND EXPOSURE

is done when the material is damp and the surrounding area is damp, advantage may be taken of natural draft. Under moist conditions, fire may be started at more than one point in a long row.

Burning brush in piles. This is the most common method of brush disposal, and is a very simple procedure when done correctly. Frequently, however, the piles of debris are made too large. As they burn, the heat becomes intense, and a tremendous draft is created. This carries into the air large sparks which can travel considerable distances before dying out. Likewise, the heat engendered prevents workmen from properly guarding the fire, with the result that nearby material catches fire and the flames spread.

As material is cut, raked, or gathered, it should be put in small compact piles, not more than about five feet in diameter and two feet in height. If the material is thoroughly dry, the fire should be started at the top of the pile; otherwise the fire should be started at the side

COLLECTING BRUSH AND BURNING ON ONE PILE

away from the wind. One pile may be burned, and surrounding piles may be carried to the fire and fed to it gradually and carefully. On wet days several such fires may safely be kept going simultaneously.

Unless conditions are very favorable for the start and spread of fire, the best method of disposing of brush and other debris is to burn it as the work of clearing progresses. The brush may be placed in small piles, which are set on fire, and as each piece of brush is cut it is placed upon the flames. Occasionally it may be necessary to add some thoroughly dry material to keep the fire going, but this will not often be

the case. As the cutting proceeds, new fires are started at convenient places. Most people are surprised to see that green brush burns as readily as it does. The advantage of this method is that large piles of brush and consequently large fires are avoided. Labor is saved, because everything is cleaned up as the work proceeds, and brush need not be handled a second time. Men need not go over the area twice. If a fire starts to spread, the whole force of men is available to meet the situation.

SPECIAL CREW NEEDED

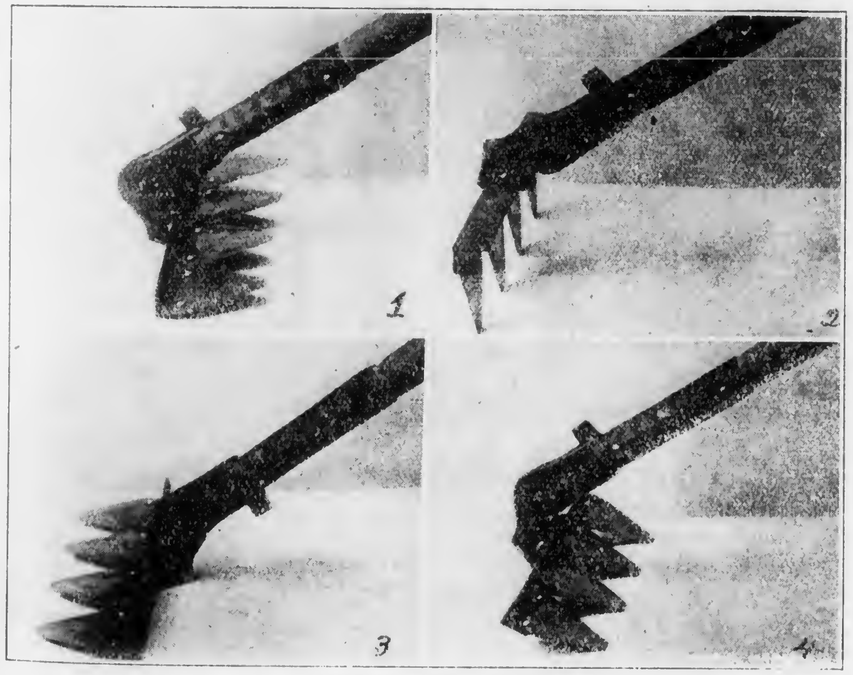
In larger operations one man or several men should have charge of the burning, and responsibility for the handling of the fire and guarding against its spread should be definitely placed. Of course, every man on the job should know the danger of fire and should exercise care at all times.

WHAT TOOLS ARE NECESSARY

There are certain tools that may be used to make the work of brush burning easier and safer. Of course, one's hands and some matches may be sufficient, but usually they are not.

A four-tined fork, such as is common on the farm, is very valuable to pick up scattered material and place it on the piles or on a fire.

An iron rake, such as a garden rake, a Rich forest fire tool, or



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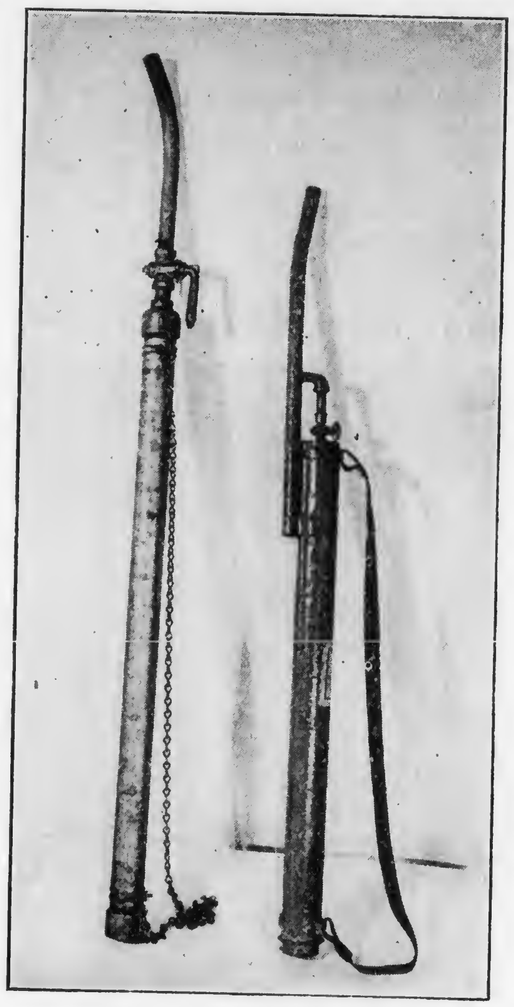
Forest Fire Tool

INTENTIONAL SECOND EXPOSURE



TORCH FOR BURNING BRUSH

other type, is useful to rake up the finer material, to keep cleaning up around the edge of the fire, to rake together the embers when the fire has burned down, to rake out a line of fire which may spread from the burning pile or row

For starting fire in brush piles or rows, a torch of any kind is better than matches. A pipe torch several feet long is very good, as the flame can be held for some time at any place in the pile. A blow torch may be needed if the material is very damp. The fuel in a torch will enable the flames to burn long enough to dry out enough of the wood or leaves to start the fire. With care the remainder may be burned all right. With a torch, brush may be burned even when it is very wet, when it is raining, or when the brush has been under snow.

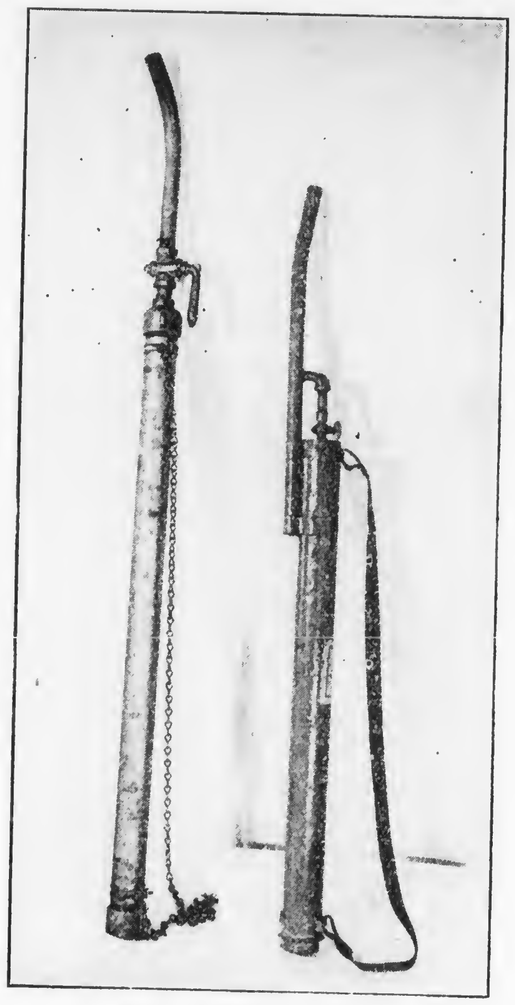
Water should always be on hand when brush is to be burned, except when the ground is covered with snow, when it is raining, or just after rain has fallen. A sprinkling can, a spray tank, or ordinary buckets may be used. The essential thing is to have a quantity of water available, so that if sparks start fires, or a fire starts to spread, the flames may be extinguished immediately. Water containers should not be emptied and left so. They should be refilled at once.

Other tools may be used when available, but the important thing to remember is that when nothing is provided with which to restrain the fire to the place it belongs, this lack of precaution is the best indication of carelessness on the part of the one doing the burning.

BEFORE BURNING BRUSH NOTIFY FIRE OBSERVERS

The State has a system of forest fire observation stations, which are manned constantly from about March 15 to June 1, and from September 15 to December 15. When the observers see smoke in or near forest areas, they notify the nearest forest fire warden, who gets a crew of men and goes immediately to extinguish the fire. The warden and his men are paid by the State for their time and expenses. If they find that the smoke which the towerman sights is not a forest fire, they may stay to see that everything is safe and that no forest fire occurs. In order to save this expense to the Commonwealth, every one who burns brush in or near a woodland between the dates just mentioned should notify the nearest tower-man who is likely to see the smoke.

In case burning is done and the fire does escape, the nearest warden should be notified at once so that a force of men can suppress the fire promptly. In such a case, the person who is doing the burning should pay the warden and his men immediately for their time and expense, taking a receipt from each one paid.



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INTENTIONAL SECOND EXPOSURE

YOU PAY FOR EXTINGUISHING FIRES YOU CAUSE

In every case where the Department of Forests and Waters can determine the cause of a fire and place the responsibility upon a person, that person is asked to pay the cost of extinction. He may also be sued for the violation of the law which prohibits the setting of forest fires.

When a person permits his fire to escape from his land to the property of another, the person damaged may collect through the courts an amount sufficient to cover his loss. It is wise therefore to exercise the greatest precautions when any fire is used in the open.

SPECIAL INSTRUCTIONS*

A. WHEN WE SHOULD NOT BURN BRUSH

1. Between March 15th and June 15th.
   Between September 15th and December 15th.
2. On a clear quiet day any time in the year when the forest floor is dry.

B. WHEN WE MAY BURN BRUSH

1. It is desirable to mow and burn at the same time, except during the fire seasons.
2. From December 15th to March 15th.
   From June 15th to September 15th.
3. When the forest floor is damp and there is a noticeable dampness in the air.
4. When snow is on the ground.
5. At night.

C. HOW TO BURN

1. Arrange cutting in windrows or in piles.
2. The best and recommended manner is to burn brush in small piles, which are regularly placed and without confusion, burning one pile and feeding on it the brush from other piles nearby, which operation will result in the least number of piles or embers.
3. Burn down hill.
4. Burn against the wind.
5. Piles should be five feet in diameter and 18 inches high and may be taken care of by two men under the worst conditions.

*Quoted in full from Orders of P. P. & L. Co. 7-25-27.

6. Five or six fires may be taken care of by one man if the ground and forest floor are quite wet.
7. Stop lighting fires early in the afternoon in order to be absolutely sure that the embers are extinguished at the end of the day.
8. After burning, it is advisable to have a man visit the spot early next morning.
9. Watch fires and piles of embers carefully during lunch hour.
10. Equipment should comprise torches for back firing and igniting piles, Rich fire tools, rattan brooms, and not less than four water tanks equipped with pumps. At least two tanks must be full at all times.

D. HOW NOT TO BURN

1. Do not pile cuttings in windrows along the edge of right of way.
2. Do not permit a spray tank to be empty, but refill at once.
3. Do not burn on rocky areas. It is safer to let the brush lie unburned.
4. Do no burn up hill, i. e., do not light the fire at the down hill side.
5. Do not burn with the wind, i. e., with the wind behind the fire.

FOREST FIRES CAUSED BY BRUSH BURNING IN PENNSYLVANIA

YEAR	Number of Fires	Per Cent of Total Fires	Area Burned (acres)	Per Cent of Total Area Burned	Estimated Damage	Per Cent of Total Damage	Cost of Extinguishing	Per Cent of Total Cost
1913	102	10.9	31,036.00	8.035	$50,594.05	7.032	$2,859.20	10.715
1914	65	5.5	18,142.85	5.036	27,989.95	3.901	1,777.77	5.676
1915	75	7.0	14,448.25	4.242	33,846.75	3.87	2,113.96	7.786
1916	61	6.0	8,553.00	5.969	13,008.25	5.141	881.79	6.408
1917	141	7.4	24,770.28	8.658	42,698.11	7.752	2,402.98	8.847
1918	115	7.1	17,420.50	7.658	43,960.40	10.705	2,242.55	8.838
1919	77	8.105	9,654.75	7.625	20,904.50	7.482	1,107.60	8.35
1920	104	6.512	12,189.70	4.759	30,739.90	3.05	2,050.34	4.756
1921	139	5.77	11,033.10	5.852	22,701.80	6.885	4,426.76	7.264
1922	244	6.712	21,474.07	6.462	42,895.80	6.401	12,406.18	6.705
10-year average	112	7.1	16,872.25	6.43	32,933.95	6.222	3,226.91	7.535
1923	212	5.990	20,509.70	5.450	61,402.37	7.726	9,873.08	6.210
1924	92	4,605	6,463.82	6.750	10,375.50	5.080	4,201.05	6.580
1925	283	11.040	14,923.42	11.924	33,451.25	8.794	8,249.89	9.617
1926	266	9.120	20,516.31	9.150	61,990.45	5.225	14,632.38	8.250
1927	103	8.270	5,049.75	13.402	18,065.25	18,750	3,355.14	11.640
5-year average	191	7.8	13,492.6	9.335	37,056.96	9.115	8,062.30	8.459

THE MONT ALTO
STATE FOREST TREE NURSERY

Bulletin 49

PFW i. 3
Sep. 1

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
CHARLES E. DORWORTH, *Secretary*
JOSEPH S. ILLICK, *Deputy Secretary and State Forester*

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George A. Retan
George S. Perry
Tom O. Bradley

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INTENTIONAL SECOND EXPOSURE

STATE FOREST COMMISSION

Charles E. Dorworth, Chairman
Edward Bailey
Mary Flinn Lawrence (Mrs. John W.)
N. P. Wheeler, Jr.
A. J. Odenwelder, Jr.

ORGANIZATION OF DEPARTMENT OF FORESTS AND WATERS

Charles E. Dorworth, Secretary
Joseph S. Illick, Deputy Secretary and State Forester
George H. Wirt, Chief, Bureau of Forest Protection
Alfred E. Rupp, Chief, Bureau of Forest Management
Charles R. Meek, Chief, Bureau of Forest Extension
Irwin W. Gleason, Chief, Bureau of Forest Lands
R. Lynn Emerick, Chief, Bureau of Forest Research and Information
Jacob M. Hoffman, Chief, Bureau of Forest Parks
W. Erdmann Montgomery, Chief, Bureau of Accounts and Maintenance
Charles E. Ryder, Chief Engineer, Water and Power Resources Board

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THE MONT ALTO FOREST TREE NURSERY

INTRODUCTION

THE Mont Alto Forest Tree Nursery is one of the pioneer forest tree nurseries of the United States. It was established in 1902 by George H. Wirt, who was the first and, at that time, the only technically trained forester in the State forest service of Pennsylvania.

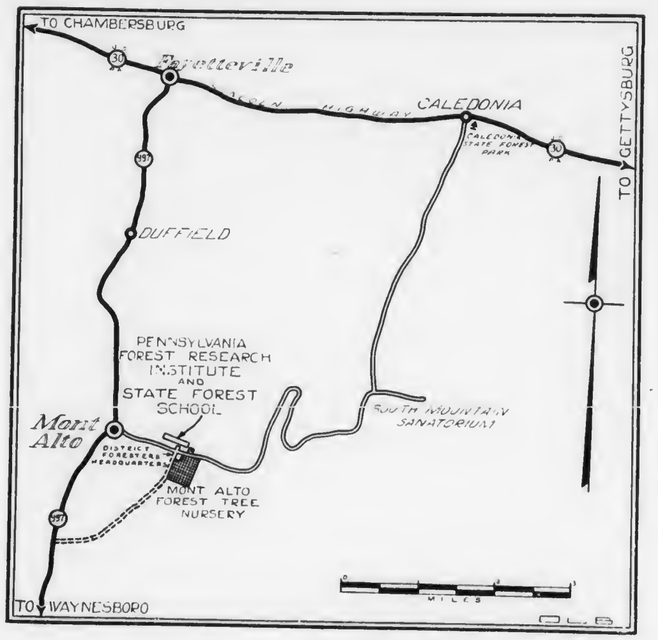
Immediately after the nursery site was selected, enough ground was plowed and harrowed for the laying out of 36 seeds beds, each four feet wide by 79 feet long. The first seed (white pine) was sown on April 28, 1902. In the Spring of 1903, the first trees—1,600 two-year-old transplants—were removed from the nursery for reforestation purposes. They were planted in "The Monaghan Field" on the Mont Alto State Forest, near the present location of the South Mountain State Sanitorium. The next year (1904) a total of 7,700 trees was taken from the nursery, and in 1905 the number shipped increased to 15,000. During the first five years (1903-1907), the output of the nursery totalled 97,281 trees. The total output was increased to more than 2,000,000 seedlings and transplants during the second five-year period (1908-1912).

The purpose in establishing the Mont Alto Nursery is recorded in numerous printed and unpublished reports. These reports show a twofold purpose: first, to help reforest the extensive waste lands in the Commonwealth; and second, to furnish private forest landowners with planting stock, free of charge, or at a nominal cost *(40, 41, 42, 44)*. In a large measure, this early vision of possible services and benefits has already been realized.

A review of the records of the Mont Alto Nursery shows a rapid and regular increase in production. From a very modest beginning in 1903, when only 1,600 trees were lifted from the nursery beds, the output has increased, until during the last five years (1925-1929) from two to four million trees have been shipped each year. In the 27 years that this nursery has been in operation, more than 35,000,000 seedlings and transplants have been grown and distributed for reforestation purposes in all sections of Pennsylvania.

WHERE MONT ALTO NURSERY IS LOCATED

The Mont Alto Nursery is located on the northwestern slope of the South Mountains, in Franklin County, Pennsylvania. It is approximately six miles northeast of Waynesboro and 12 miles south of Chambersburg, in the well-known South Mountain fruit belt. This location is unusually well adapted to nursery work because of the general climate, the long growing season, and the protection afforded by the neighboring forest-covered mountains.



Location of the Mont Alto Forest Tree Nursery

The annual rainfall in this region averages about 39 inches. The mean temperature is 52° F. The average date of the last killing frost is the first of May, whereas the first killing frost in fall does not occur, on the average, until October 12. These figures, however, do not picture the full advantages of the location of the Mont Alto Nursery. In spring, it is usually possible to begin the work of lifting trees from the beds as early as March. Ofttimes it is not necessary to mulch the trees for winter protection before Thanksgiving Day, and sometimes not before Christmas. The rainfall is fairly evenly distributed throughout the year, and long droughts are infrequent.

The Mont Alto Nursery is easily reached by following a concrete road that branches from the Lincoln Highway at Fayetteville, and runs to the village of Mont Alto. An improved road, leading from that village, passes the nursery, goes through the Mont Alto State Forest, and climbs the mountain to the Mont Alto State Sanatorium. Near the nursery is the State Forest School, which is a branch of Pennsylvania State College. Here, too, is the Pennsylvania Forest Research Institute of the Department of Forests and Waters.

HOW THE NURSERY WAS STARTED

In 1902, George H. Wirt, the first professional forester in the State forest service of Pennsylvania, was sent to Mont Alto to start forest work. His first task was the establishment of the Mont Alto Forest Tree Nursery *(1, 21, 41, 42)*. Immediately after the nursery site was selected, the ground was plowed, harrowed, and laid out in 36 seed beds, each four feet wide by 79 feet long. Six pounds of white pine seed were purchased at $2 a pound, and 10,000 one-year-old white pine seedlings at $4 a thousand. On April 28, 1902, the first seed was sown. The sowing was done by Augustus Varnicle, a local blacksmith, who had expressed doubt that white pine trees ever grew from seed. In one bed a pound and a half of seed was sown broadcast. The remainder of the seed was sown in drills across the beds. The 10,000 white pine seedlings were dibbled in and placed in rows across the beds.

The first summer was hot and dry. Billets of wood were placed between the drills to conserve moisture. Water was carried from the nearby creek and applied to the trees with sprinkling cans. Shades were made of woven wire fence, cut into lengths of 10 to 12 feet, to which were nailed one-half-inch by two-inch laths. Some of these old screens were in use more than 25 years. Although 5,500 of the transplants survived, losses were excessive, and the germination of the seed was unsatisfactory.

On September 3, 1902, William Daywalt, a farmer who lived on the nearby mountain, delivered a wagon load of white pine cones. There were 56 bushels in the load. From these cones 41 pounds of seed were obtained. Mr. Daywalt also delivered one-half bushel of white oak acorns for $1.50. Twenty pounds of seed were bought and sown in the Fall of 1902, and 20 additional pounds of native seed were sown in the Spring of 1903. These were the first sowings of forest tree seeds in the State nurseries of Pennsylvania. In addition to this seed sowing in the nursery, extensive plantings of chestnuts, to be exact, 2,436 hills, were made in the Mont Alto Forest by Forest Ranger Ford Sylvester, in November, 1902.

In 1903 the Pennsylvania State Forest School was started at Mont

Alto. Immediately thereafter the size of the nursery was increased. Much of the work in the nursery was done by students as a part of their regular course of studies. The nursery formed an integral part of the school, and, together with the Mont Alto Forest, was a centre for work in silvical research and practicum. Table I on page 51 lists all the foresters who have been in direct charge of the Mont Alto Nursery since its establishment in 1902.

GROUND PLAN OF NURSERY

For many years the layout or ground plan of the Mont Alto Forest Tree Nursery was arranged primarily to facilitate hand labor. It was blocked off into sections of about one half of an acre or slightly larger in size. These sections were subdivided into beds four feet wide by 25 feet long, and the resultant standard bed of 100 square feet has always been used as a unit for seed sowing, bookkeeping, and management purposes *(39)*. With the increased use of horse and motor-drawn implements, along with transportation by truck, it is no longer advantageous to have the ground subdivided in this manner. Beds are now laid out in greater lengths, thus reducing to a considerable extent unnecessary turning with trucks and implements.

When lands are irrigated, fertilized, and cultivated intensively for the production of a valuable crop, excessive waste spaces between production areas are a liability. At Mont Alto an effort has been made to reduce the amount of "path area" to a minimum. This reduction of space given up to paths has led to a considerable reduction in the cost of weeding and general management expenses.

SOURCES AND COLLECTION OF FOREST TREE SEED

At the start of the Mont Alto Nursery, some seed was collected locally and some was purchased *(41, 44, 47)*. In later years, considerable quantities of seed were purchased from seed-collecting stations that were started in the Lakes States and in New England. Even today a large portion of the seed used at Mont Alto is necessarily purchased from sources outside of the State. Especially is this true of evergreen tree seed, such as the pines and the spruces. These trees the uncertain seed producers. With them, a year of plentiful seed production is usually followed by several years of scanty seed production. Hence, only those regions where there are still large stands of mature timber can be depended upon for regular supplies of seed.

It is now generally known that the best seed to plant in any given region is seed produced by trees within that region. Through heredity, such seed produces trees that are adapted to the climate of the region. Hence, these trees usually make better timber than do trees

The Site of the Mont Alto Nursery in April, 1902

General View of the Mont Alto Nursery in 1904, Two Years After Its Establishment

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SOURCES AND COLLECTION OF FOREST TREE SEED

At the start of the Mont Alto Nursery, some seed was collected locally and some was purchased *(11, 14, 17)*. In later years, considerable quantities of seed were purchased from seed-collecting stations that were started in the Lakes States and in New England. Even today a large portion of the seed used at Mont Alto is necessarily purchased from sources outside of the State. Especially is this true of evergreen tree seed, such as the pines and the spruces. These trees the uncertain seed producers. With them, a year of plentiful seed production is usually followed by several years of scanty seed production. Hence, only those regions where there are still large stands of mature timber can be depended upon for regular supplies of seed.

It is now generally known that the best seed to plant in any given region is seed produced by trees within that region. Through heredity, such seed produces trees that are adapted to the climate of the region. Hence, these trees usually make better timber than do trees

The Site of the Mont Alto Nursery in April, 1902

General View of the Mont Alto Nursery in 1904, Two Years After Its Establishment

INTENTIONAL SECOND EXPOSURE

grown from seed procured in foreign countries. It is, therefore, the practice in the operation of the State nurseries of Pennsylvania to secure as much seed as possible from sources within the Commonwealth. In the case of the hardwoods, it has been easy to secure ample supplies. Walnut, oak, maple, and ash trees seed frequently, and the seed is easily collected. As early as the Winter of 1903-1904, seed of the black locust was gathered about Mont Alto and sown in the Spring of 1904. In 1906 approximately 37 bushels of walnuts were gathered. Some of the oldest plantations in the State, such as those in the vicinity of Mont Alto and the Caledonia State Forest Park, were made by planting seedlings grown in the Mont Alto Nursery from local seed.

The fine stands of natural white pine in Mont Alto Park and on the flats near New Baltimore were recognized, even at the time the nursery was started, as possible sources of good seed. In 1902, 65 bushels of white pine cones were gathered, and cones have been collected from the trees in these stands every seed year since that time.

On the occasion of that first seed harvest in 1902, the collected cones were laid on a tight attic floor to dry, and the seed was then shaken out. In 1905, 50 bushels of cones were gathered, yielding 37 pounds of cleaned seed. That year a seed-drying establishment, with a capacity of 50 bushels, was equipped in an old brick building *(49)*. The equipment consisted of several tiers of hardwood lath trays, with muslin trays at the bottom to catch the seed as they were shaken out. The handling of seed in this special manner is probably the very first instance of such practice by any state.

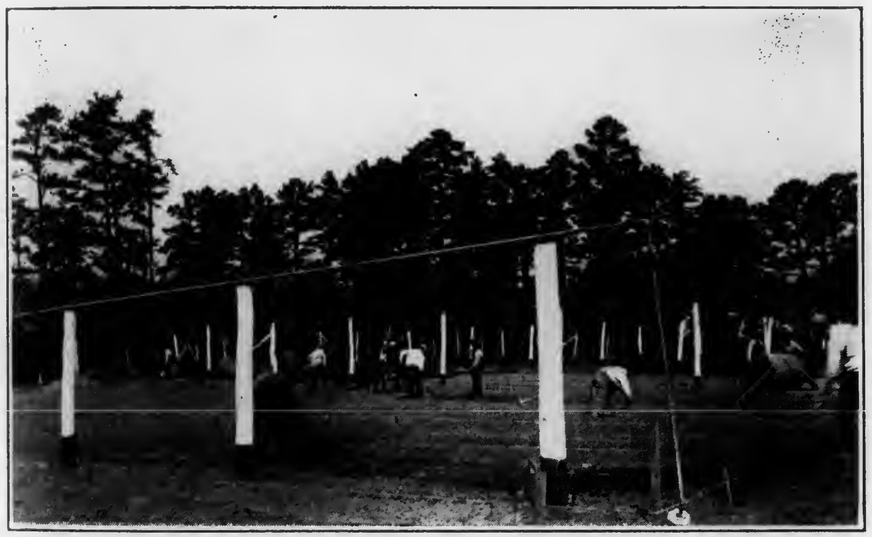
To facilitate the practice of securing home-grown seed for the nursery, special plots, known as seed supply stations, have been set apart in various forest plantations in the near-by forests. These plots are tended primarily for seed production, and the trees kept under close observation. Thus, it will be possible to secure additional quantities of native seed as soon as these plantations have reached seed-bearing age. The first of these special seed supply stations was established in 1927 by State Forester Joseph S. Illick in a plantation of Scotch pine in the Mont Alto State Forest, and in a natural stand of white pine near the Greenwood Forest Tree Nursery, in Huntingdon County.

HOW SEED IS SOWN IN NURSERY BEDS

The seed of most trees, especially that of evergreens, is very tiny This necessitates the careful preparation of the soil before the seed is sown. At Mont Alto the practice is to plow the soil as deeply as possible, and then pulverize it by dragging and harrowing. The next step is to throw up seed beds by using a "middle-buster" plow. (See

illustration, page 30). This implement is like those used in the South for ridge-plowing sweet potatoes. By the use of this plow a great economy in labor is effected. For many years it was the practice to do this work by hand-spading.

After the beds are thrown up in the rough, they are marked out by stakes and twine, and then smoothed off by hand-raking. The raking is a very important operation. It is done thoroughly, all lumps and stones are removed, and the surface of the bed made as fine and smooth as that of a well-cared-for vegetable garden. The beds are finished with a slightly convex surface to facilitate drainage. They are raked to a width of slightly more than four feet, so that, even after the edges have been worn away, the seeded bed will still be a full four



Nursery Crew Preparing Beds for the Sowing of Seed

feet in width. These beds are raised about four inches higher than the paths that separate them. The paths themselves are 18 inches wide. These 18-inch strips include the unsown edges of the beds.

The practice of making seed beds in this exact and precise manner has been adopted after much experimentation. Beds and paths of varying widths have been tried. For many years, beds 25 feet in length were used, with wide paths across the ends. These wide paths proved to be unnecessary and were an actual hindrance to the use of labor-saving devices. When beds of other widths were used, they were found to be wasteful, for sometimes hardly 50 per cent of the area of the beds contained seedlings. Under the present practice, beds may be as long as the sections in which they are located, but they are seeded in strips 50 feet long. Spaces one foot wide are left bare between these 50-foot seeded strips.

In the beginning of nursery operations at Mont Alto, all seed was sown in drills, according to the practice followed at that time in European nurseries. It was soon learned that this method was uneconomical, and wasteful of seed, time, and nursery space. Much of the seed did not germinate until the second year after it was sown, because it was covered too deeply with earth. The number of seedlings produced in a bed was relatively small. Where large numbers were produced, the seedlings were of extremely variable quality because of the crowding within the drills. It was found that broadcast sowing produced better seedlings, prevented much winter heaving, as well as excessive mud-coating during severe rainfall, and helped in overcoming attacks of disease. Because of these factors, the final cost of seedlings grown from seed sown broadcast is only about one half of the cost of seedlings grown in drill-sown beds.

A Few Special Seed Beds are Spaded with Shovel

All seed sowing is now done by hand. No other method gives an even distribution of seed. It is the practice now to sow seed somewhat more densely near the edges than in the centre of a bed, in order to obtain in a more even growth of trees. Formerly, the quantity of seed to be sown on any given area was weighed out. This took considerable time, as it made necessary the preparation of a small quantity of seed at each sowing. Now it is the practice to weigh out at once the seed needed for a large unit of ground, and prepare this for sowing. From this larger amount, seed is measured out for sowing single beds. Small

containers have been made which measure accurately the amount of seed needed for these small planting units. This practice greatly facilitates the work of sowing.

The seed of all conifers is treated, prior to sowing, by being moistened and coated thinly with red lead *(13)*. Originally, it was believed that this practice prevented damage by birds at the time of germination, and also aided in warding off diseases. It is now known that this is not true; but the practice is continued because the red color makes the seed visible on the ground, and enables the sower to do his seeding evenly. It also tends to insure proper covering of the seed. Twine, fastened to stakes, and stretched along the edges of the bed, guides the sower in seeding the beds.

The seed of some heavy and rapid-growing hardwoods, such as black walnut, oak, and black locust, is sown in drills, which are made with a horse cultivator. Sowing these tree seeds in this manner is necessary in order to facilitate the digging of the seedlings, whose long taproots make the tree-lifting operation difficult at best.

Sugar maple, ash, white oak, and tulip poplar make much better growth when sown broadcast. In the ordinary seed bed they can be shaded during the period of germination, and they are more easily weeded. Formerly, it was believed that wide drill sowing and horse cultivation would make weeding easier, but recent experiences have proven this untrue *(19)*.

The quantity of seed sown in any given area varies with the quality of the seed and the number of trees desired per unit of area. When the Mont Alto Nursery was started, relatively large quantities of seed were sown, because of heavy seedling losses. In consequence of this heavy seedling, the seedlings shipped from the nursery were often thin and spindling. The improvement of soil conditions has cut down these losses very considerably. Extended nursery studies have proven that smaller quantities of seed produce better results.

Where, originally, 20 ounces of white pine seed were used to 100 square feet of bed surface, the quantity was cut to 16 ounces by 1913. Later, the amount was reduced to 12 ounces. At present, only eight ounces are used to each 100 square feet of bed surface. If the seed is of good quality, this quantity is ample.

In the same way, the quantity of seed of other trees used for sowing has been reduced, until at present the approved seeding practice calls for the following quantities of seed for each 100 square feet: red pine, four ounces; pitch pine and shortleaf pine, five ounces; Scotch pine and Norway spruce, six ounces; European and Japanese larch, seven ounces. These quantities of seed should give final stands of 2,500 to

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INTENTIONAL SECOND EXPOSURE

5,000 seedlings per 100 square feet. This rate of density insures the best possible growth and quality in the seedlings.

The quality of the seed used is determined by careful germination tests. These are made under conditions as nearly natural as possible. When fall sowing is practiced, germination tests can not always be made. In that case, only the cutting test is applied. Experience shows that fall sowing will produce germination in practically every sound nature seed. The mere cutting of the seed with a knife shows what percentage of the seed is well filled.

In the case of most seed, it is advisable to make nursery sowings at the same periods at which seed sown by nature falls from the trees. However, there are some exceptions to this rule. At Mont Alto, after earlier partial failures, renewed trials of fall sowing were made in December, 1913, when nine beds were seeded to white pine. The experiment was successful. Next year 30 beds were fall-sown. So favorable were the results, that ever since that time fall sowing has been preferred in raising white pine seedlings.

The advantages of fall sowing are earlier and better germination, less loss during dry summer weather, better growth because of longer growing period, reduced loss from disease, and greater economy of time during the busy spring nursery season. The heavier hardwood seed is always sown in the fall.

GENERAL SEED SOWING SCHEDULE

The following table shows the prevailing practice in regard to the seeds of various trees which have been planted at Mont Alto:

Species	*Time[1] for Seed Sowing, and Other Treatment[2]*
White pine	Oct. 15 to Dec. 15 or early spring
Western yellow pine	Oct. 15 to Dec. 15 or early spring
Red pine	Early spring
Pitch pine	*April* to May 15 or latest autumn
Shortleaf pine	May to *June* 15
Scotch pine	*Early spring* to June 15
Austrian pine	*Early spring* to May 10
Japanese red and black pines	*Early spring* to May 10
Table mountain and scrub pines	May
Jack or Banks pine	*April* 15 to May 30
The larches	*April* to May 15 or latest autumn
Hemlock	*Autumn* or stratify until earliest spring
Norway spruce	*April* to July 1
Other spruces	April 15 to *May* 15
Arborvitaes	*April* 15 to May 15
Firs	*Late autumn* or earliest spring
White ash	*Autumn* or stratify until early spring
Oaks	*Autumn* or stratify until early spring
Green ash	*Autumn* or early spring
Hackberry	*Autumn* or stratify until spring
Black locust	May—after soaking or heating
Honey locust	April or *May*—after soaking
Tulip poplar	*Autumn* or stratify until spring
Basswood	Stratify in autumn and sow *early second* succeeding spring
Walnuts	*Autumn* or stratify until spring
Wild black cherry	*Early autumn* or stratify until spring
Ash-leaved maple	*Autumn* or early spring
Sugar maple	*Autumn* or stratify until earliest spring
Red and silver maples	As soon as ripe in spring
Norway and sycamore maples	*Autumn* or stratify until early spring
Elms	As soon as ripe in spring
Sycamores	April 15 to *May*
Catalpas	April 15 to *May* 30
Hickories	*Autumn* or stratify until spring
Mulberries	Mix with moist sand and stratify until *spring*

[1]Italics indicate most desirable time for sowing.

[2]Tree seeds, for which stratification is recommended, should never be permitted to become thoroughly dry. Even if they are sown in the autumn, viability and vitality may suffer from storage in heated rooms or long exposure to direct sunlight.

HOW THE SEED IS COVERED

When the seed is sown, it is pressed into the surface soil of the seed bed by a hand roller, wide enough to cover the entire bed, including both seeded surface and unseeded margins. This roller is concave, so as to fit the slightly convex surface of the bed. The use of the roller not only firms the bed surface, so that it will not easily erode or develop hollows, but it also makes it possible to cover the seed evenly without disturbing it. After the seed is properly rolled in, it is covered with a thin layer of sifted material, which is not more than two or three times the thickness of the seed itself.

This material may be compost, or a mixture of sand and compost, or charcoal and compost *(38, 39)*. It must be a mixture which will not bake, as does clay, or set, as pure sand does, and which will not

Seed Sowing is Done by Hand. The Seed is Covered with a Thin Coating of Sifted Compost

easily wash off, as too light a compost does. This cover material is distributed by being placed in a long-handled box sieve, which is shaken over the bed. The use of a finely meshed sieve enables the operator to regulate the depth of the covering. Two men handle the sieve and a third man keeps it supplied with covering material.

HOW NEWLY MADE BEDS ARE PROTECTED

It is necessary to protect the surfaces of nursery beds, which have been fashioned with care, from the force of heavy rains, and from birds and rodents which may discover the newly sown seed. Likewise, it is necessary to conserve at the surface of the soil the heat and moisture necessary for the germination of the freshly sown seed.

This is accomplished by covering the beds with a satisfactory mulch. The first mulch ever used at the Mont Alto Nursery, and which is also probably the best mulch, consists of white pine needles. When the nursery was small, it was possible to secure enough of these needles for mulching. But when the nursery grew larger, it became necessary to try other materials. Straw, paper, burlap, and leaves have been used at different times. Ordinary straw is usually full of weed seed. Clean rye straw, cut before maturity, makes the best straw mulch. What is known as tobacco-bundle paper was used as early as 1909, and works very well, especially over a thin coating of other material as it keeps out the birds *(39)*. However, it is difficult to handle, and it may blow off during windstorms. Burlap gives excellent results, saves labor and storage space, but is expensive. Any cover must be weighted down with screens to hold it in place.

As germination time approaches, the beds must be carefully watched. As soon as the seed is breaking evenly through the ground, the mulch must be removed. If the mulch is allowed to remain on the beds too long, the tiny, coniferous seed cases, which are pushed up on top of the growing plants, will penetrate the cover, and the tender seedlings will be pulled out in quantities when this cover is removed.

The tree seedlings in the beds must be covered during the first winter to prevent their being heaved out of the soil by the frost. At Mont Alto the clayey nature of the soil aggravates the damage from heaving. Hence, various methods have been tried to overcome this evil.

Records of the first decade of the Mont Alto Nursery show that even seedlings that had been covered were heaved out. Drill sowing increased the possibility of damage from heaving. During the first winter, sticks and billets of wood were laid between the drills, and these were covered with needles or leaves. It was soon found that leaves make a poor covering, and pine needles provide the best cover. These needles, if worked closely in between the trees, give good aeration and afford sufficient protection. As the Mont Alto Nursery grew larger, and the yearly fall of needles did not supply enough winter cover material, straw was used more and more, and has proven to be a fairly satisfactory material for this purpose.

At Mont Alto the winter covering is applied about the middle of November and removed in April, or even earlier, according to weather conditions. When it grows warm early in the year, the cover must be removed to prevent moulding. Yet it must not be taken off too early lest the alternate thawing and freezing of early spring heave the seedlings out of the ground. Naturally, heaving is most likely to occur near the edges of the beds, and, accordingly, the mulching material is applied somewhat thicker along the border.

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INTENTIONAL SECOND EXPOSURE

As soon as the mulch has been removed, and the seed is exposed, large numbers of birds often flock to the nursery. The most practicable way to protect the seed beds is to hire a squad of boys to patrol the nursery and frighten the birds away. Birds are most injurious in the early morning. Hence, it is necessary to have the boys on hand at a

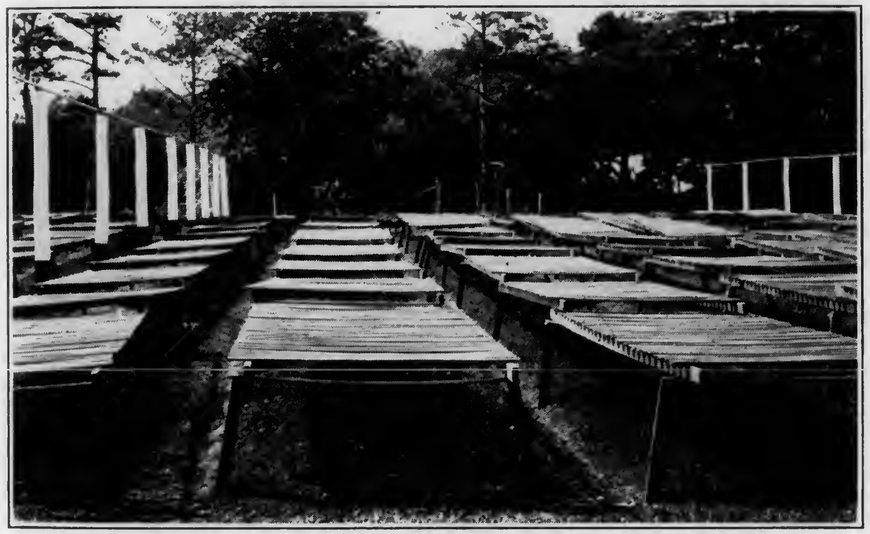
Seed Beds Mulched with Straw for Winter Protection
Screens are Laid on the Straw to Keep It in Place

very early hour. At the season of the year when fall-sown coniferous seeds germinate, white-throated sparrows are migrating northward. They are likely to appear in flocks very suddenly, and disappear just as quickly. But very often they leave behind them many ruined beds, and always a considerable bill for watchers. Spring-sown seeds germinate later and usually suffer less from birds. Eternal vigilance is necessary if the plantings are to be protected from the feathered raiders.

YOUNG TREES ARE SHADED

The sudden removal of the mulch from the seed beds exposes the germinating seed to the direct heat of the sun, and tends to dry out the surface layer of soil in which the seed is bedded. It is necessary to supply some protection to both seed and soil. Protection is provided by the use of shades, also called screens, which allow only 50 per cent of sunlight to reach the beds. Stakes are driven along the edges of the beds at regular intervals, and wooden strips are laid across the beds, each strip resting on the tops of opposite stakes. These strips are nailed fast to the stakes, and the shades are laid on the strips.

The shades are of a length convenient for handling. The first ones used at Mont Alto were made of a patent fence material composed of heavy laths fastened in woven wire. These were both heavy and expensive. Later, shades were made according to the following specifications: two strips of one by two-inch lumber were used for a frame, and to these strips ordinary building laths were nailed. The laths were spaced one lath-width apart, so that if complete shading was desired, loose laths could be laid between the permanent laths in the screen. A shade of this sort gives alternate strips of sunlight and shadow on the beds. As the sun moves, the strips of light and shade move with it. Thus, no plant in the seed bed is exposed to direct sunlight nor to shade for a very long period. Shades made of laths have proven to be so satisfactory that they have been the standard shades since they were first used.



Seeded Beds are Protected by Shades Made of Laths Nailed to Long Strips of Wood and Set on Low Frames

Shades are kept above the little trees throughout the first growing season. The artificial shade so made produces in the seed bed a condition of sunlight and shadow very much like that found in the forest, and so is well suited to the growth of the little trees. In some years, the shades have been removed long before the end of the growing season. Experience has shown that it is not absolutely necessary to keep the beds shaded for more than six or eight weeks. But too early removal of the shades makes growth conditions difficult for little forest trees, encourages vigorous weed growth, and the seedlings produced are not as well developed as are those grown under shades.

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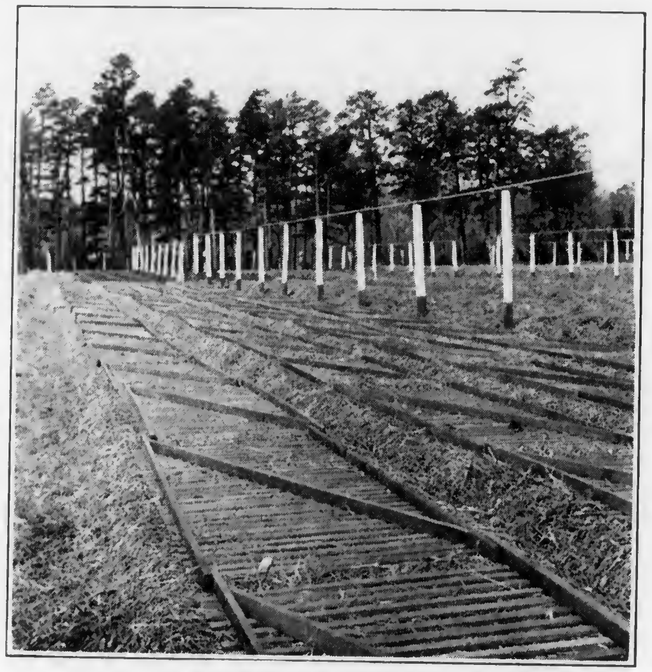

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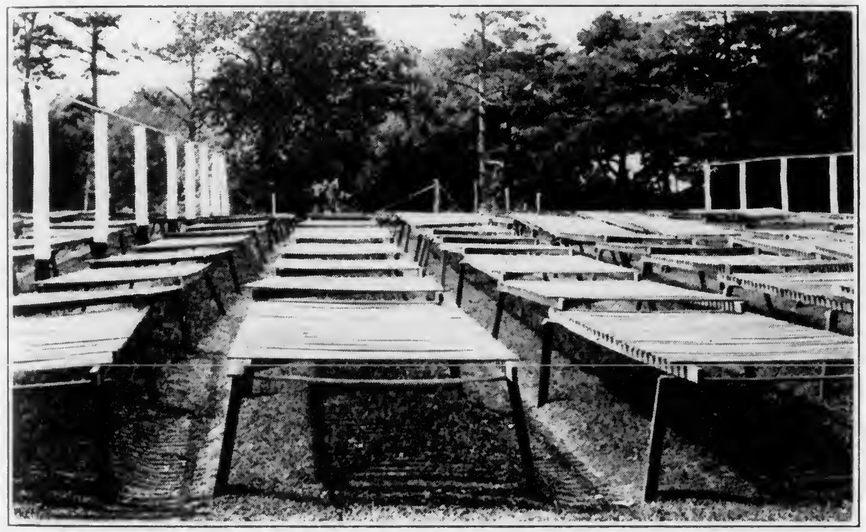

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INTENTIONAL SECOND EXPOSURE

General View of Eastern Section of Mont Alto Nursery in 1922 Before Overhead Irrigation System was Installed. Semi-Portable Water Line Supported on Stakes about Three Feet High is Shown in Center

General View of Eastern Section of Mont Alto Nursery After Overhead Irrigation System was Installed

if it is possible to do it. The roots of all trees are unfavorably affected by the drying out of the soil in which they grow. Older trees, with roots that penetrate deep into the ground, are perhaps little affected by the drying of the surface layer of soil; but the roots of tiny seedlings lie entirely in this surface layer. Until these little trees develop sufficient foliage to shade the soil in which they stand, and produce deep penetrating roots, it is advisable to keep the beds shaded.

YOUNG TREES REQUIRE PLENTY OF MOISTURE

During the critical period of growth, before the tiny roots have penetrated into the moist layers of soil, little trees must have plenty of moisture. An overhead sprinkling system is now installed throughout the entire producing area at the Mont Alto Nursery. Trees of all ages are watered freely throughout the growing season.

The water for this sprinkling system is supplied by a reservoir, which is connected by a gravity line with the "Tarburner Spring." This reservoir, built in 1909, and located on a hillside above the nursery, gives an ample supply of water at all times. It is connected with the nursery by a four-inch pipe line, so that there is ample pressure at all times. Before this system was installed, water for sprinkling purposes was obtained through a semi-portable pipe-line system. The reservoir serves as a warming basin, where the cold spring water loses its extreme chilliness; for water that is too cold when applied to the germinating beds not only retards germination, but also hinders the growth of the seedlings. The modern sprinkling equipment makes it possible to soak the beds thoroughly in any portion of the nursery. Fine sprays of water fall on the beds from tiny overhead nozzles. The general practice is to apply the water during the early morning hours and at evening time, and avoid its application during the middle of the day.

WEEDING—AN IMPORTANT NURSERY PROBLEM

From the time that the mulch is removed from the beds, up to the first frost in autumn, there must be constant weeding of the beds *(7)*. Pulling the weeds not only removes an injurious influence, but it also serves to cultivate the soil. It keeps the ground around the seedlings open and light. Weeding of this sort is naturally all hand work, and, hence, is expensive. Every known method for checking the growth of weeds has been tried, but nothing has been found to equal hand-weeding.

It might be thought that keeping the weeds down so carefully would result in their eventual elimination. This has not proven to be the case. Weed seeds constantly blow into the nursery. The straw that is used for mulching doubtless contains some weed seeds. In one way or another, weed seeds constantly find their way to the nursery.

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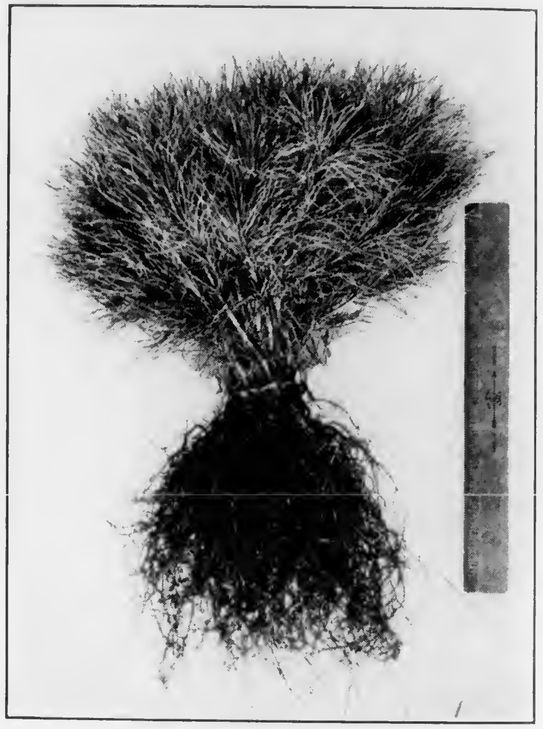
INTENTIONAL SECOND EXPOSURE

Weeding must begin very early. Weeds must be pulled before they are so large that their removal seriously loosens the roots of the tiny trees, which break off very easily. Accordingly, great care must be used in weeding, which makes it a slow process. To get careful weeders is difficult, for weeding is not easy work. Neither is it work for which a large wage can be paid. Yet, despite its cost, weeding is believed to be cheaper and more effective than the sterilization of the soil before sowing.

When a bed contains a good stand of seedlings, there will be little need of weeding in the second summer. The dense stand of little trees will tend to choke out most weeds. Nevertheless, during the two or three years that a bed is occupied by the trees, the adjacent paths will need to be cleaned regularly. This can be accomplished easily by hand-hoeing and horse cultivation.



A Bundle of Fifty
Two-Year-Old White Pine Seedlings

The compost pile is the place for organic refuse material, such as straw that has been used two or three times for mulch and winter cover, leaves and needles that blow into the nursery, and grass and weeds that are cut or pulled in the nursery, together with stable manure. This pile is turned over at regular intervals during a period of two years. At the end of this time all the vegetable matter has thoroughly decayed, and has been well mixed with the earth that was also deposited in the pile. This well-rotted compost is not only an excellent fertilizer, but makes the very best mixture to sift on the tops of beds after they have been seeded.

LITTLE TRANSPLANTING IS DONE

In the State forest tree nurseries of Pennsylvania, the aim is to produce large quantities of trees that are large and strong enough for forest planting purposes. In most commercial nurseries, on the other hand, the aim is to produce relatively larger-sized trees to be

used for ornament or shade. To produce such trees, transplanting one or more times is necessary. Trees suitable for reforestation purposes can be grown without transplanting. Thus, it is possible to avoid the expenditure of time and money that is required in the production of transplants. During the early years of Pennsylvania forestry, considerable transplanting was done at Mont Alto. During the first year of the Mont Alto Nursery, 10,000 one-year-old white pine trees were bought from a commercial nursery and transplanted in the local nursery. In 1910 fully 500,000 trees were transplanted. But the loss through winter heaving was so heavy that the added expense of transplanting was not justified.

A Bundle of Fifty
Two-Year-Old White Ash Seedlings

At the present time, the practice in the Mont Alto Nursery is to transplant only a few trees of standard stock which are to be grown for ornamental plantings, as well as exotics and other special trees that are to be kept for several years. This transplanting work is usually done in the spring. When such work is done in the fall, it should be completed before September 15. This permits good root growth before freezing weather arrives. Experience has shown that spruce trees may be transplanted at any time up to the first day of December.

When transplanting is done at Mont Alto, the Bietsch Transplanting Board[1] is used. This implement permits the handling of trees of varying sizes at the same time, and yet insures their being set at a proper depth. It is a narrow board, four to six feet in length, equipped with coiled springs set at regular intervals. The trees to be transplanted are held upright in the board by these coiled springs. One board will hold 30 to 60 seedlings. The boards are loaded by laborers and then carried to the trenches where the trees are

[1] Developed by Forester Tom O. Bietsch when in charge of the Greenwood Forest Tree Nursery at Greenwood Furnace, in Huntingdon County, Pennsylvania.

to be planted. The trenches are always dug with square-pointed shovels, and are made with perpendicular sides. A guide board or trenching board is laid along one edge of the trench, to keep the tree row straight. The transplant board is held upright in the trench, while earth is drawn into the trench and pressed down against the roots of the seedlings, thus holding them in position. The transplant board is then removed, and the trench completely filled with earth. Thus, the trees are mechanically spaced and lined. This perfect alignment and spacing makes cultivation an easy matter.

During the process of transplanting, the seedling trees must be protected with care, and the roots exposed to the air for the briefest period possible. Water is applied to the beds as soon as the transplanting is finished. During the first summer after transplanting, the beds are very carefully cultivated. Should the transplanting be done in the fall, the beds must be well proteeted during the suceeeding winter. Protection is desirable even during the second winter following the transplanting.

HOW TREES ARE LIFTED, SORTED, AND COUNTED

Most nursery trees are shipped in the spring, although at Mont Alto a few trees are shipped during the fall. Spring shipping begins about the last of March or the first of April, and continues for two or more weeks. The Mont Alto Nursery is fortunately situated in regard to shipping. Sometimes tree lifting starts as early as the middle of March, and, therefore, shipments can be made as early as it is possible for planting to be done in any section of the State. The largest shipment of trees took place on March 17, 1919, on which day 1,000,000 trees were shipped from the Mont Alto Nursery. Trees can be shipped to the northern sections, and there they can be kept until the frost is out of the ground, when they can be planted immediately. This is a great advantage to the planter. If he is a farmer, he can get his trees planted before farm work begins. If he is to plant great numbers of trees, he can get help cheaply at that season. At this time of year, too, trees are more resistant to damage done in planting, and are especially resistant to exposure. Furthermore, the spring rains can be depended upon to give the little seedlings a good start.

In the earlier years of the Mont Alto Nursery, it was the practice to loosen the roots of the little trees with spading forks, and then pull up the plants and shake the earth from their roots. Experience has shown that this is a slow and costly process. All rocks are now removed as the beds are prepared for new seeding, and it is hoped that after 1930 all the digging can be done by machine.

The digging machine now in use at the Mont Alto Nursery is one which was designed at the Greenwood Nursery, in Huntingdon County.

Loosening Three-Year-Old Scotch Pine Seedlings Prior to Lifting Them for Shipment. The Basement Floor of the Nursery Building in the Background is Used for Packing and Shipping Purposes, and the Second Floor for Seed Extracting and Seed Storage.

Lifting Forest Tree Seedlings

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INTENTIONAL SECOND EXPOSURE

This machine consists of a wide-cutting blade of tool steel mounted on a frame of heavy channel iron. The blade is five feet long, and can be adjusted so as to cut at any desired depth. It is drawn under the bed, loosening the soil of the entire area, and heaving the little trees upward so that their roots are entirely freed. The plants are then easily lifted by hand, and the earth shaken from them. This machine is drawn by two horses, which are hitched to a long spread, so that they can walk in the paths, one on either side of the bed. The use of this machine not only saves a great amount of labor, but also makes it possible to lift the trees with less splitting, bruising, and stripping of roots than is the case when they are dug with a spading fork.

As soon as trees are dug and lifted, they are tied in great bundles and hauled to the packing house where they are counted and bunched. Here they are stored in wet moss, to keep the roots moist. In the old days, before the packing house was built, and all sorting and counting was done in the open, the tree counters necessarily sat on the ground and worked with bare hands. Hence, this work could then not be carried on in severe or stormy weather. Therefore, periods of unfavorable weather greatly hindered the work of shipping. Now it is possible to lift trees in almost any sort of weather, and the trees are counted and bunched in the packing house, where it is warm and comfortable. Tree lifting now goes steadily forward each spring without interruption.

Formerly, when the trees were counted out-of-doors, it was difficult to avoid exposing the roots to the drying action of sun and wind. It is most important that the roots of little trees be protected in handling (See "Seedling Exposure Studies," page 39). This can easily be done in the packing house. One man is detailed to see that the trees are kept sufficiently moist during the counting operation. He also regularly examines the bundled trees to see that they do not mould or heat. As a rule, it is possible to make shipments promptly after the trees are counted and bundled.

As forest tree seedlings are sold by number, they must be counted accurately, and tied in small bundles of convenient size. Usually there are 50 trees to the bundle. The trees must also be sorted and graded. When seeds are sown broadcast, there may be in the seed bed, by the end of the second year, sections where the stand of seedlings is thin and sparse, whereas in other parts of the bed the stand may be very dense. In still other parts, the trees may be rather evenly spaced. These varying conditions affect the growth of the trees noticeably. Where the stand is thin, the individual trees are usually strong and healthy. If there are trees that are small and puny, they are probably of poor heredity. Such trees are thrown away. Where the stand is dense there may be many thin and spindling

seedlings, which are nevertheless of good stock. Of these, only the very poorest are discarded. There may also be trees with injured roots or tops. Some may have poor buds, or show other evidences of prospective failure should they be planted in the open. Most of these trees are thrown out, though the best of them are sometimes transplanted into the nursery. Only strong, vigorous stock is allowed to go to the planter. The work of counting, grading, and sorting is very important and is supervised carefully. This is particularly true at Mont Alto, as this nursery ships many trees to private planters throughout the State.

If forest tree planting is to be successful, planters must be supplied with trees that will make good growth. Where planting is to be done in grass or brush lands, stronger and better stock must be used than

Sorting and Counting Seedlings

is necessary when abandoned fields are planted. By careful grading, such as is done at Mont Alto, it is possible to supply each planter with the kind of stock he particularly needs. Before 1920, two-year-old seedlings formed the bulk of the nursery shipments. Three-year-old trees have been used in larger numbers in recnt years. Transplanted trees are not usually shipped until they have been in the transplant bed at least two years, as the growth made in the first year after transplanting is mostly root growth. When seedlings do not grow too densely in the bed, they attain sturdy and vigorous roots and stems by the end of the third year.

TREES REQUIRE CAREFUL PACKING FOR SHIPMENT

The nurseryman must guard against two things when he is shipping

trees to planters. If the trees are not packed in wet moss, and if adequate provision is not made to retain the moisture about the roots, they may dry out and the trees die. If the trees are packed so tightly that the tops do not get air, they will likely heat and mould, and thus be severely injured or even killed.

Before the shipping season arrives, it is necessary to have on hand a plentiful supply of moss, containers of various kinds, waterproof wrappers, and other shipping material. When thousands of seedlings are packed and shipped in a single day, the organization of the work must be planned carefully and carried out efficiently. Otherwise, there will be mistakes and delays. The shipping season is very short, and consequently the work must go forward as fast as it can be pushed.

Since 1913, knockdown, corrugated, cardboard boxes or cartons have been bought in quantity. These are quickly set up. A single box, depending upon its size, will contain from 500 to 2,000 seedlings, packed in damp moss and wrapped in waterproof paper. The packing must provide against dripping. To insure a plentiful supply of air, the boxes have numerous perforations. When the packing is faulty, the warm air in post offices and railway cars causes heating.

In order that advantage may be taken of the cheapest express shipping rates, the individual crates should weigh not more than 150 pounds. The wet moss in a package makes it excessively heavy for its size. This necessitates containers that are strong enough to prevent breakage. If a box does break in transit, the trees are usually scattered about and dry out so completely that many of them die.

The Mont Alto Nursery makes many of its own crates. Since 1914, the Mont Alto sawmill has supplied the nursery with lumber of specified sizes of crate material. This lumber can be assembled quickly into crates which will hold 2,000 to 5,000 trees each. The crates are made up during the winter, when outside nursery work is at a standstill. Crates are packed so that the tops of the little trees are around the edges, or at the ends, and the roots are in the middle of the crate. Layers of wet moss are packed between layers of roots. Wooden crosspieces are fastened inside the crates to hold the tree bundles in place, and to prevent the roots from becoming exposed to the air.

Since 1923, most express shipments of trees have been packed in crates of wire and veneer construction. This has aided greatly toward lower transportation charges on trees, as this type of crate is light but very strong because of the four or five wires that run around and securely bind the package. The crates of this type are bought in two sizes in carload quantities. They arrive knocked down, and are set up as time permits, so as to be in readiness when shipping season comes. These crates hold from 1,000 to 5,000 trees, depending on species and age of stock.

A Truck Load of Seedlings Leaving the Nursery

Great care is taken when trees are shipped to label them in such a way that the planter knows exactly the different kinds he has received for planting. All shipping tags, forms, and invoices are made out in advance of the shipping season, in order to expedite the work.

LABOR-SAVING MACHINERY

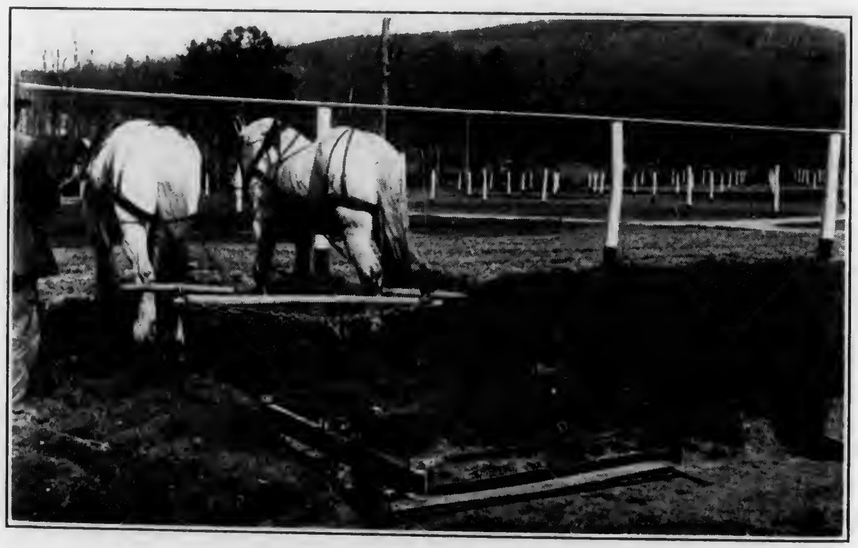
Two machines that save enormous amounts of labor have recently been introduced at the Mont Alto Nursery. They are the "middle buster" plow for throwing up beds, and the combination root pruner and tree digger.

The "middle buster" plow is a standard factory product, and is commonly used in the southern Coastal Plain Region for throwing up sweet potato, corn, and cotton rows, where ridge-farming is practiced. It does the same work as the specially made plows used at the Clearfield and the Greenwood nurseries. As it is a standard factory-made implement, it costs less than one third of the price of these specially made implements, and is lighter and more convenient to handle.

The tree digger is of the type developed at the Greenwood Nursery several years ago. Although made of four-inch channel iron, it can be carried about by two men. Its lightness is probably its only advantage over the Clearfield digger. As this implement is still rather new, it will probably be further improved. The saving of labor, though great, is not the main benefit obtained by the use of the tree digger. There is a minimum loss of fine roots in trees lifted by this implement.

The common plow, the harrow, the disc, and the drag have been used

Preparing Nursery Beds with a "Middle Buster" Plow. This Implement Eliminates Much Hand Spading



Horse-Drawn Seedling Lifter

for many years at the Mont Alto Nursery in preparing the soil for seeding.

NURSERY BUILDINGS

The nursery area at Mont Alto was originally the site of several dilapidated houses and outbuildings. Not one of these was suitable for use as a packing house, or even for the storage of tools and supplies. These buildings were consequently torn down, and the best of the siding and timbers sufficed to build the frame portion of the old stone packing house, which was constructed in 1910. This building, only 16 by 18 feet inside, served its purpose well. Its form of construction made it essentially a storage cellar. It was sunk into the hillside, and had thick stone walls and a cement floor. The windows were double, enclosing insulated air spaces. Above this cellar is a low attic for dry storage of supplies and certain types of seeds.

In 1921 a new building was erected on the bank of the Little Antietam Creek, across the road from the lowest part of the nursery. The upper part of this building was designed for seed drying and extraction during the fall and early winter. In spring and summer it served for storage, and supplemented the lower floor as a place for sorting, packing, and shipping trees. This building was 20 by 40 feet in size. Although it was well adapted to the purpose it served, and was very useful, it was never really adequate to meet the need for space. The location was satisfactory, permitting all downhill hauling of stock. So long as wheelbarrows and pushcarts were the approved means of transportation, this feature was of great advantage; but with the use of motor trucks, this advantage has disappeared. At present, the shipping work is largely handled in the south end of the large barn now used for State forest and nursery purposes. This barn once stood on the site of the building now occupied by the Pennsylvania Forest Research Institute and the Pennsylvania State Forest School. It was moved to the eastern edge of the nursery in 1925, and was renovated and greatly improved in 1928. Its upper floor was always a spacious storage space for crates, crating material, and moss. The floor of this barn has been concreted throughout. The greater part of it is used as shed space for wagons and trucks. During the shipping season, it is used as a place to count, store, and pack trees. A large room at one end is heated and is used for counting. The unheated portion is used for tree storage. This building provides more than 2,000 square feet of floor space, which permits rapid and orderly handling of trees. In 1929 most of the trees handled were lifted and shipped in less than one week. Thus, the planters received their stock early, and the nursery force could turn their attention to other spring tasks in the nursery.

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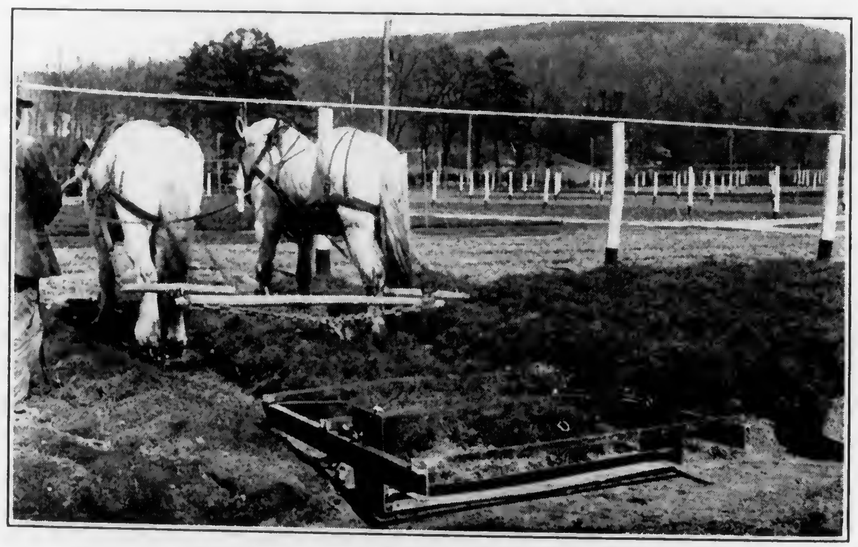

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INTENTIONAL SECOND EXPOSURE

middle of the nursery. It is of frame construction, with a concrete floor 16 by 20 feet. Its central location saves much time, and thus adds to the efficiency of the laborers. In the Spring of 1929, a large frame building was erected for storage of straw and other litter used for bed covering.

The present buildings at the Mont Alto Nursery are large enough to allow for considerable expansion of the nursery.

KEEPING ACCURATE NURSERY RECORDS

The Mont Alto Nursery was one of the first nurseries, if not the very first nursery, in this country to develop a system of records and accounts. The beginning was made in 1906, when a system of special nursery forms was developed. At the annual meeting of the Pennsylvania State foresters held at Harrisburg in 1910, a paper was read by Forester Ralph E. Brock, then in charge of the Mont Alto Nursery, that dealt with the use of these special nursery forms. Experience showed that these first forms were too complicated. In 1912, and again in 1913, a new system was worked out by the five nurserymen then in charge of State nurseries. These systems were given their first trial at Mont Alto, and revised forms were later put into use in all the State nurseries. Since then this system has been slightly modified, but it has been the basis of all the records kept.

The forms used at present provide for a summary of costs per unit of area. One sheet is used for each age-class of each kind of tree grown in the nursery. The original entry is posted directly in this summary sheet. At the end of the year, the general costs are prorated on the basis of area. Thus, at the end of two, three, or more years, it is possible to say just what the given area has cost, and to determine the cost per thousand of the trees grown in it. The sheet also shows the total expense for each type of work carried on, and for the material used. In 1913, for the first time, there was made and published in the Department report, a complete statement of the costs of the Mont Alto Nursery *(36)*. This report was itemized to show the cost of raising each kind of tree.

During the nine-year period from 1921 to 1929 inclusive, the total net operating expense of the Mont Alto Nursery was $97,628.03. This includes depreciation and supervision, but does not cover charges for interest on the investment, and land rental.

The output of the nursery during the above period was approximately 24,415,000 trees of the following age classes:

One-year-old seedlings	2,390,000
Two-year-old seedlings	11,250,000
Three-year-old seedlings	10,500,000
Seedlings four years old or older	125,000
Transplant stock	150,000

From the above data, it is seen that the average cost per thousand for all trees has been $4, which, in most instances, includes cost of digging, sorting, packing, and transportation of trees to the planter. The approximate production cost of stock of different ages, follows:

One-year-old seedlings (mostly hardwoods)	$5.50
Two-year-old seedlings	3.00
Seedlings three years old and older	4.50
Transplants	8.00

SPECIAL NURSERY STUDIES

One or several special study projects of a research character were initiated every year in the Mont Alto Nursery. Many of these investigations have yielded results of great value, and have made it possible to grow many kinds of trees of good quality at a low cost. Unfortunately, many of these special study projects were carried on by busy men, burdened with details of nursery administration along with teaching or the manifold duties that a district forester must perform. As a consequence, the progress and conclusions of many of these experiments were not recorded as fully and accurately as is desirable in special research studies.

Six of the special research studies conducted in the Mont Alto Nursery, for which full and conclusive records are available, follow:

1. Experiments with Fertilizer.
2. Damping-Off and Shedding Disease Studies.
3. Methods of Combating White Grubs.
4. Mice Damage and its Control.
5. Experiments in Root-Pruning.
6. Seedling Exposure Studies.

1. EXPERIMENTS WITH FERTILIZERS:

From the very beginning of operations at the Mont Alto Nursery, the poor soil structure prompted experimentation to find means of improving this soil so as to insure better tree production. Stable manure and lime were tried first. They did not solve the problem. Several studies were made, covering a large number of nursery beds, in an effort to find some combination of mineral fertilizers that would prove successful. One of these studies was undertaken in 1913 in the Mont Alto, Greenwood, and Asaph Nurseries to determine the effect of mineral fertilizer on the growth, quality and yield of seedlings, and on the maintenance and improvement of soil fertility. These fertilizer experiments included the application of nitrate of soda, acid phosphate, sulphate of potash, sulphate of ammonia, bone meal, floats, and dried blood. These, and some other fertilizer materials, were applied alone and in different combinations. Numerous check

plots were maintained throughout the experimental area. A full description of these experiments is given in the 1914-1915 report of the Pennsylvania Department of Forestry *(30)*. Another fertilizer experiment, carried out in 1925-1927, covered nearly 200 nursery beds.

There are certain common conclusions which were arrived at in all these nursery fertilizer studies. The use of fertilizers tends, on the whole, to increase damping-off. There is little evidence of any positive benefits received from the use of fertilizers, except possibly in the case of bone meal and phosphates. Even where benefits were found, these benefits were less than those discovered in check areas where soil amendment measures had been applied to better the texture and physical condition of the soil. The studies showed conclusively that the heavy clay soil at Mont Alto was not deficient in plant food. The unsatisfactory tree growth was due to the fact that the plant food in the soil was not available. The mineral plant food was not in such form that the little trees could make use of it.

The earliest attempt to improve the structure of the Mont Alto Nursery soil was through the use of wood ashes. This was not successful. Then the use of green manures was tried. This method was not successful at first, probably because it was not carefully followed up. In 1912 experimentation with charcoal began. This was followed up intensively a year later, with further applications of charcoal. Many favorable results were secured, among them being: (a) better soil texture, (b) less damping-off, (c) better germination, and (d) less heaving. The application of charcoal was followed by plowing under green manures, with the addition of barnyard manure on fallow areas. This treatment rapidly increased the productivity of the nursery. The charcoal used in the Mont Alto Nursery was procured from a waste pile left at the site of the Mont Alto Iron Furnace. As the supply of this local charcoal became limited, sawdust and bark from the nearby State forest sawmill were used with success, after they were well rotted in compost piles. This form of compost is decidedly acid in character and is thus favorable to the development of evergreen seedlings.

2. DAMPING-OFF AND SHEDDING DISEASE STUDIES:

Damping-off is a menace to many greenhouse, garden, and nursery plants. Practically no evergreen seedlings are immune to it, though some are less susceptible than others. The disease is caused by many kinds of fungi, which cause the decay of the tender stem or root structure. The newly germinated plants, when attacked, droop quickly and fall over. The most common of these fungi attacks the seedlings near the surface of the ground. Some even attack the seed, and cause it to decay before it has germinated. These fungi are most active in warm and humid weather. Like the common molds with which most

people are familiar, they do not thrive in sunlight or where the air is dry.

Practically all nurseries suffer some losses from damping-off. When epidemics occur, whole beds of newly germinated trees may fall prey to this dreaded disease within one or two days. After the trees become hardened or woody, they are less likely to be attacked. Perhaps more research in the Mont Alto Nursery, as well as elsewhere, has been conducted for the purpose of obtaining knowledge of these low forms of plant life and their control, than concerning any other line of nursery practice.

Experiments in relation to damping-off were made from the very beginning at the Mont Alto Nursery. For years, losses from this cause were so high that at one time the question of abandoning the growing of evergreens at Mont Alto was considered seriously. The use of charcoal as a soil amendment was the first uniformly successful step taken to combat this serious trouble. It was noticed that losses materially decreased in the beds treated with charcoal *(30, 38)*.

Following the lead of Dr. Frederick V. Coville, of the U. S. Department of Agriculture, nurserymen began to work on the theory that an acid soil condition would stop the trouble. Sulphuric acid was used in many nurseries, but was thought to be too expensive to be practicable at Mont Alto. From 1915 to 1917 an experiment was carried out with acid leachings and raw humus *(39)*. These experiments tended to confirm the idea that a natural acid soil condition, secured by the use of plenty of vegetable matter, was the best preventive. The nursery has consequently been conducted in accordance with this idea, and the losses from damping-off have been reduced to a relatively low figure for most species.

In 1924 an elaborate experiment was conducted in cooperation with the U. S. Department of Agriculture. This experiment only confirmed the previous conclusion, that not one of the chemicals used was as valuable as a proper natural condition of the soil.

Experience at the Mont Alto Nursery has shown that once damping off has started, spraying with slightly acid Bordeaux mixture, after each rain or watering, helps materially.

After the little trees become large enough to crowd each other and compete for food and moisture, they may show spots where the needles are turning brown. Sometimes this condition is due to lack of water. Usually, however, it is caused by the attack of fungus diseases. Spraying with Bordeaux mixture about every two weeks is the most practical and effective control measure against these diseases. Experience at the Mont Alto Nursery indicates that the spraying should

be done in dry weather, though not in the heat of the day, when it might cause scalding. If the Bordeaux mixture is applied in powdered form, the danger of scalding is averted. Some nurserymen do not believe that scalding is caused by midday watering or spraying.

3. METHODS OF COMBATING WHITE GRUBS:

The larvae of the May bettles, commonly called white grubs or grubworms, often do serious damage to practically all evergreens in both seedling and transplant beds *(19)*. During certain years, the loss of trees from this cause exceeded the losses from all other causes combined. The most serious injury wrought by these grubs is done in nursery beds of small, one-year-old stock. Sometimes the larvae will completely strip the rootlets of large seedlings and transplants, then eat the bark away, thus killing the trees. Three or more species of white grubs have been found in the Mont Alto Nursery. All seem to have the same feeding habits, and probably require two growing seasons to attain full development.

The control measures that have been tried at Mont Alto to prevent damage by grubs follow:

(a) Destroying the adult beetles commonly called May beetles. Experience has shown that this form of control is almost futile.

(b) The large grubs can be hunted to advantage and dug out in first-year seed beds. As these insects eat the roots of the small trees, they pull the plants down into the earth until the needles are in contact with the soil. Such trees do not turn brown at once. They may even replace their lost roots and start to grow again, when conditions are moist and otherwise favorable. If all these damaged trees are pulled out of the beds, and an experienced man looks over the beds on successive days following the grub damage, it is possible to locate and kill many of the grubs by digging at points where new attacks are detected by the presence of trees that have been pulled down into the ground.

(c) Small sticks, the size of lead pencils, or even larger, were dipped in coal tar and stuck into the beds here and there, and left in the soil. This treatment was found to be effective for only a short period of time, and was tedious to apply.

(d) Decoy hardwood trees of white ash and elm were planted among the evergreens. This was only partially successful.

(e) Powdered lead arsenate was hoed and raked into the seed beds at the time of sowing seed. Amounts varying from 200 pounds to 2,500 pounds per acre were applied to beds by working the powder into the upper three or four inches of soil. This work was planned by representatives of the Pennsylvania Department of Agriculture.

It was successful insofar as eliminating the grubs was concerned, but it had markedly injurious effect upon the growth of most trees. This experiment was tried on sycamore, white pine, Norway spruce, red pine, Scotch pine, and pitch pine trees. Of all these species, the Scotch pine seemed to be injured least by the lead arsenate. Injury was less pronounced on the finer textured soils.

(f) At the Greenwood Forest Tree Nursery, in Huntingdon County, and later at the Mont Alto Nursery, beds infested with white grubs were flooded until the soil was so saturated that the grubs were driven to the surface of the ground, where they could be gathered and destroyed.

4. MICE DAMAGE AND ITS CONTROL:

During occasional years, several species of rodents have increased so greatly in numbers at the Mont Alto Nursery as to become serious pests. The short-tailed field or meadow mouse has done the greatest injury to trees in Mont Alto Nursery in the past. The common house mouse and the long-tailed or white-bellied woods mouse are mainly to be feared in the seed house or in seed beds before germination occurs. The short-tailed mouse is not only a seed eater, but will also eat the bark and cambium from stems and upper root regions of many tree species during their seedling stage of life. The damage may be especially bad in densely set beds of white pine during their second and third winters in the nursery beds, when they offer warm shelter as well as food for the mice.

During the severe Winter of 1917-1918, some beds of two-year-old white pine lost 75 per cent of their inventory by mice damage. In 1926-1927 the loss was also serious, probably due to cleaning up the wooded environs of the nursery, thereby driving the mice into the beds for protection.

Strychnine is the best means of combating the mouse plague. The usual application of poison was made by mixing one fourth of an ounce of strychnine sulphate with eight quarts of oatmeal and a small pinch of saccharine. Water was added until a dough was formed which was distributed through and around the nursery in pellets about the size of an acorn. These were placed in the thickest beds, or under shades, stone piles, rocks, and hedge rows where the poison could not readily be taken by other larger animals or birds. In 1928 specially designed glass flasks were purchased which absolutely guard against other animals getting poison. Wheat soaked in a strychnine solution is not used in these flasks. They can be exposed anywhere about the nursery, and the bait they contain is readily replenished when it is seen to have disappeared.

Skunks and other predatory animals or birds may also be encouraged and protected so as to prevent the increase of mice. The distribution of poison, however, nearly always results in the death of all such creatures as may eat dead mice. It should, therefore, be resorted to only when absolutely necessary.

Moles are a net benefit in the forest nursery. They feed largely on insect life, and prefer above all else the larvæ of the May beetle or June bug, commonly called white grubs. These grubs are a serious nursery pest in occasional years. Tunnels and hills made by moles result in the loss of a few trees by drying out or burial, but these may well be sacrificed if an entire bed is thereby guaranteed against grub damage.

5. EXPERIMENTS IN ROOT-PRUNING:

Root-pruning was tried early in the operation of the Mont Alto Nursery. The first black walnut seedlings grown at Mont Alto in 1906 were root-pruned. These trees were later planted out in land adjacent to the nursery, and now form a promising plantation. The first hardwoods shipped from the nursery were all root-pruned. In 1912-1913 an experiment was tried on one-year-old black walnuts, whose roots were very long. When the planting stock was dug, about 100 trees were set in transplant rows, after having their taproots reduced to lengths varying from six to 12 inches in length. Results at the end of the year were uniformly unsatisfactory. Few or no trees had died, but all showed imperfect healing of the cut in their taproots, with considerable evidence of rot advancing upward. Growth was also somewhat reduced by this treatment.

Root-pruning studies of white pine seedlings were made in 1921 *(17, 18)*. More than 100 perfectly sound, normal trees were dug for the experiment. Each tree was robbed of half or more of its root system. In 50 of these trees, the main root was split with a knife, beginning at a point about an inch below the root crown, so that half of this main root was cut away, along with half of the lateral roots. In 50 other trees, the root systems were shortened to half the length they showed after reasonably careful digging. All the trees thus altered were then transplanted in an unwatered but fairly moist bed, together with an equal number of similar trees that had not been root-pruned. The season that followed was unusually dry. Nevertheless, the crippled and root-pruned trees survived remarkably well, slightly surpassing, in this respect, the check trees, and making nearly as good height growth as the check trees. At the end of the second year, the trees that had been root-pruned were larger in every respect.

When trees of both groups were dug and examined, it was found that the root-pruned trees had developed more lateral and more fibrous

roots than the unpruned trees had. This examination was made at the end of the first year.

During this same growing season, a study was made of the effect of pruning the roots of trees soon after germination. This study dealt with black walnut, white walnut or butternut, red and white oak, box elder, and white ash trees. The seed of these trees had been sown either the preceding fall or early in the Spring of 1921, so that all the seed had germinated by late April or early May. On the twenty-fifth of May several fine seedlings of each variety were selected and pruned **in situ,** by passing a long-bladed sharp knife underneath the trees, at a depth of two to three inches below that at which the seed had been planted. Whenever a tree was root-pruned, this tree and a near-by check tree, growing under exactly similar conditions and of similar size, were carefully marked, so that there could be no possibility of later on mistaking the pruned for unpruned trees.

At the end of the growing season, specimens of both root-pruned and check trees of all species were dug. For practically every species except the white walnut trees, root-pruning was apparently beneficial in every way. The conclusion reached was that the root-pruning of all the hardwood species studied is to be recommended, providing the pruning is done in the first year of the tree's existence. Especially should this be the practice where these trees are grown for ornamental planting.

6. SEEDLING EXPOSURE STUDIES:

Soon after nursery and reforestation work was started in Pennsylvania, it was found that there was urgent need for information concerning the length of time that little trees could be exposed to the action of sun and wind without their being stunted or killed by such exposure. Previously to 1913, several studies had been made on this subject, but they were not carefully checked. In 1913 and in 1914 careful studies were made in the Mont Alto Nursery, with proper checks *(53, 54)*. These studies showed very clearly that any period of exposure exceeding 20 minutes was harmful to trees. Many trees were killed by the exposure, and those that did survive were seriously stunted in growth during the first year. The experiments also showed that when the weather was clear and windy more trees died as a result of exposure than when there was no wind. A summary of the results of the first experiment are given in the following table:

SURVIVAL OF TREES WITH ROOT EXPOSURE OF VARIABLE LENGTHS

LENGTH OF EXPOSURE (Minutes)	NUMBER OF TREES PLANTED (April 4 and 5)	NUMBER OF TREES SURVIVING (August 2)
None (Check)	100	89
10	100	83
20	100	92
40	100	82
60	100	66
90	100	30
120	100	36
180	100	3
240	100	4
360 (6 hours)	100	4

GROWTH OF THE MONT ALTO NURSERY

The original area of the Mont Alto Nursery in 1902 was about one fourth of an acre of bed surface. From this small area the size of the nursery increased steadily. The early additions were made by demolishing dilapidated houses and fences, and improving the grounds about the original nursery site. By 1910 all the cleared land owned by the State south of the old Mont Alto Furnace site was occupied by nursery beds. This made a nursery area of approximately 10 acres. In 1924 the area of the nursery was temporarily expanded by adding to it about two acres of old orchard land, located north of the State Forest School campus. This soil was stony and unsuited for nursery use, hence it was abandoned in 1926.

In the Autumn of 1929, a tract of land lying west of the original nursery was bought for nursery use. An area of two and one-half acres was immediately broken and worked into shape for seeding in the Fall of 1930. This site is well located for irrigation and nursery management.

Tables II to VII in the Appendix give some records of the expansion of the Mont Alto Nursery in terms of the increased number of trees grown. The following table gives the number of trees shipped by years from the Mont Alto Nursery, from its beginning in 1902 to 1929:

TREES SHIPPED FROM MONT ALTO FOREST TREE NURSERY

YEAR	NUMBER OF TREES SHIPPED
1903	1,600
1904	7,700
1905	15,000
1906	51,051
1907	21,930
1908	98,286

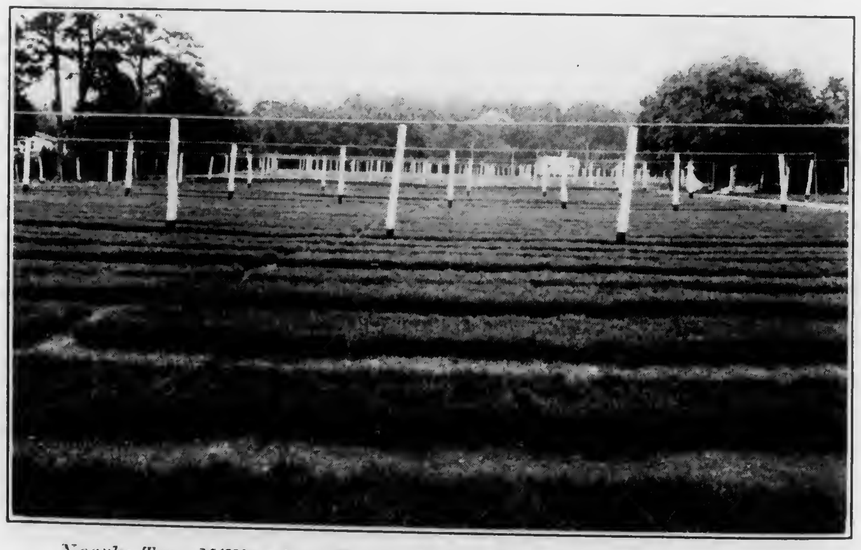
YEAR	NUMBER OF TREES SHIPPED
1909	362,633
1910	714,054
1911	439,393
1912	437,425
1913	228,705
1914	1,161,305
1915	546,857
1916	1,550,650
1917	1,620,930
1918	1,728,377
1919	1,002,017
1920	482,336
1921	1,244,543
1922	1,801,047
1923	3,167,304
1924	3,957,498
1925	2,881,930
1926	4,171,660
1927	3,620,286
1928	2,083,870
1929	1,781,017
Total number of trees shipped (1903-1929)	35,184,404

PRINCIPAL KINDS OF TREES PRODUCED

Many different kinds of forest tree seedlings and transplants have been grown in the Mont Alto Nursery. Inventories of this nursery are listed in the Appendix (Tables II to VII). These inventories do not list all the trees grown, because many different kinds were planted in the nursery in small quantities for arboretum and experimental purposes. Of the 76 different tree species grown in the nursery in 1922, only 25 were present in numbers above 10,000.

In the past, white pine exceeded all other trees grown in the Mont Alto Nursery. In recent years, serious enemies of this tree, such as the white pine weevil and the white pine blister rust, have decreased its popularity with tree planters. Because of its general freedom from enemies, red pine is now replacing white pine to some extent. A comparison of the inventory for 1928 with those of earlier years, (Tables II to VII), gives supporting information pertaining to this changing tendency in the use of trees for planting purposes. Norway spruce ranks second to white pine in the total number of trees grown. Scotch pine has been grown in numbers almost equal to Norway spruce. Pitch pine and Japanese larch are two trees that have also won favor with forest tree planters. Among broadleaf trees, red, oak, white ash, black locust, and black walnut have been produced in considerable quantities.

Dense Beds of Two-Year-Old Pitch Pine Seedlings



Nearly Two Million Two-Year-Old Red Pine Seedlings were in the Mont Alto Nursery in 1929

HOW TREES ARE DISTRIBUTED

The seedlings and transplants grown in the Mont Alto Nursery are sold by the Department of Forests and Waters at $2 per thousand for seedlings and $5 per thousand for transplants. These prices are well within the actual cost of production. In accepting trees at these low prices, the landowner agrees: (a) to plant the trees in Pennsylvania for wood production or watershed protection, (b) not to sell or remove the trees from the land until they are large enough to be used as wood products, (c) not to use the trees for Christmas trees, windbreaks, hedges, or for shade or ornamental purposes, (d) to protect the planted area as far as possible from fire, grazing, trespassing, and other damage, (e) to furnish a report on the planted area whenever requested by the Department of Forests and Waters.

Applications for less than 1,000 trees will not be accepted. One thousand trees will reforest almost an acre, if the trees are spaced six by six feet, and will cover almost one-half of an acre if trees are spaced four by five feet. The planting of less than one-half of an acre is not considered a reforestation project. An order of 1,000 trees may be made up of 1,000 trees of one kind or 500 trees of two different kinds. Less than 500 trees of one kind are not distributed.

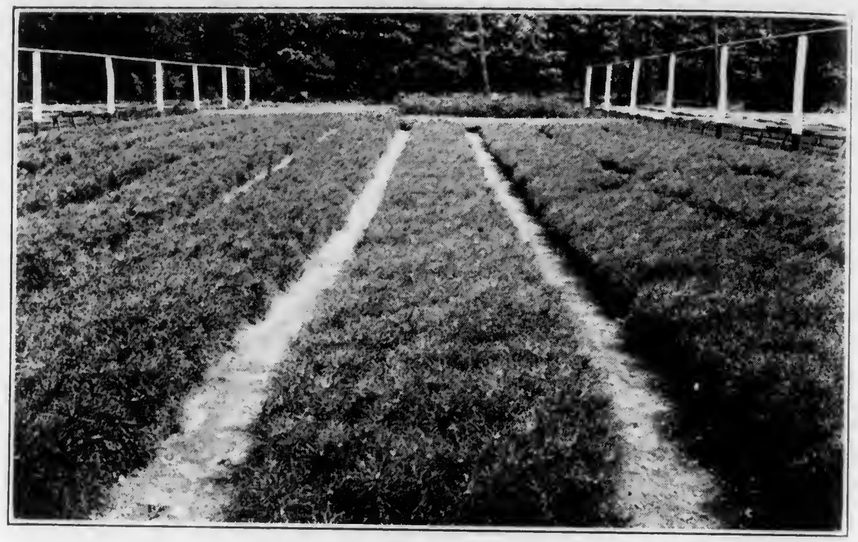
Persons desiring information on forest tree planting in Pennsylvania should communicate with the local district forester or with the Department of Forests and Waters, Harrisburg, Pennsylvania, asking for Circular 31, "Forest Trees to Plant in Pennsylvania."

SUCCESSFUL PLANTATIONS FROM MONT ALTO TREES

Trees from the Mont Alto Forest Tree Nursery have been planted in every county in Pennsylvania. Practically all the plantations on the State forests have been developed from Mont Alto trees. Among the most successful plantations in Pennsylvania, grown from Mont Alto Nursery trees, are those at the Caledonia State Forest Park along the Lincoln Highway between Chambersburg and Gettysburg, and at Pond Bank and The Old Forge in Franklin County. The older forest plantations near Cross Fork in Potter County, also at Greenwood Furnace and the Saeger Farm in Huntingdon County, and in Allen's Valley at the headwaters of the Aughwick Creek in Fulton County grew from Mont Alto trees. These plantations, now 20 to 30 years old, demonstrate how quickly and successfully small forest tree seedlings will grow into thrifty plantations, and thus convert unproductive waste land into productive forest land.

THE FUTURE OF THE MONT ALTO NURSERY

A quarter of a century of practical administration, careful experi-



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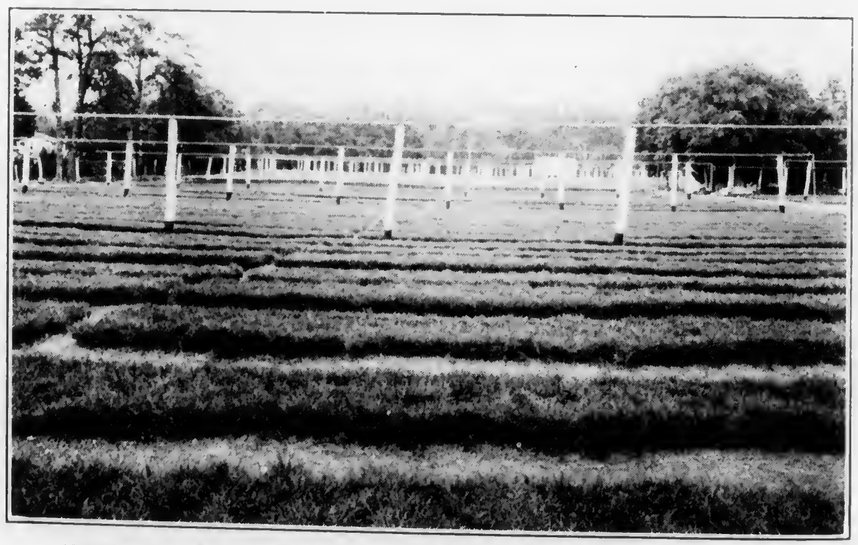

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INTENTIONAL SECOND EXPOSURE

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The primary function of this nursery continues to be the production of first-class nursery stock for reforestation purposes in Pennsylvania. From 1903, when the first trees were shipped, until January 1, 1930, more than 35,000,000 trees were shipped from this nursery. During the last five years, the annual shipments ranged from 2,000,000 to more than 4,000,000 trees. With the recent enlargement of the nursery, it will be possible to maintain an annual production of two to four million trees, and there is a possibility of a considerable enlargement of this estimated future output.

Another major service of the Mont Alto Nursery is the providing of facilities for research studies. The personnel of the recently created Pennsylvania Forest Research Institute, with headquarters within a few hundred yards of this nursery, is already engaged in the study of many reforestation problems. It is hoped that in future years much valuable forestry knowledge will be developed at Mont Alto, and that the Mont Alto Nursery will make substantial contributions to the progress of forestry.

Just as the Mont Alto Nursery has succeeded ever since its establishment, so it will continue; (a) to produce trees in large numbers for reforestation purposes, (b) to provide excellent facilities for research studies, and (c) to serve as an outdoor laboratory for the practical instruction of forestry students. The development of the Mont Alto Nursery on this threefold basis will be a big factor in the replacement of denuded forest areas, now too common in all parts of Pennsylvania, with fine forests of quality trees. When this worthy goal is reached, we can look upon the creation and development of the Mont Alto Forest Tree Nursery as a noble experiment and a valuable contribution to forest conservation.

These Planted Scotch Pine Trees, Now 20 Years Old, Started Their Growth in the Mont Alto Nursery

This Thrifty Pitch Pine Plantation, Now 15 Years Old, Grew from Mont Alto Seedlings

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INTENTIONAL SECOND EXPOSURE

The Mont Alto Nursery Produced the White Pine Seedlings That Now Make Up This Attractive and Thrifty Plantation Near Austin in Potter County

One of the Oldest White Pine Plantations Grown from Mont Alto Trees. These 20-Year-Old Trees are Rapidly Approaching Merchantable Size

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APPENDIX

TABLE I

FORESTERS IN DIRECT CHARGE OF MONT ALTO FOREST TREE NURSERY*

George H. Wirt .....Spring of 1902 to Sept. 1, 1906
Ralph E. Brock .....Sept. 1, 1906 to March 1, 1911
Tom O. Bietsch .....March 1, 1911 to Sept. 1, 1912
George A. Retan .....Sept. 1, 1912 to April 1, 1918
W. Boyd Evans .....April 1, 1918 to May 1, 1918
Joseph S. Illick .....May 1, 1918 to July 1, 1918
George S. Perry** .....July 1, 1918 to Nov. 1, 1927
Tom O. Bradley .....Nov. 1, 1927 to present date

*Mr. George H. Wirt (1902-1910), and Dr. E. A. Zeigler (1910-1927), as directors of the State Forest School, always exercised a directive and helpful advisory oversight in the management of the nursery.

**Absent on leave for two periods, during which time the nursery was supervised by:

Charles M. Geneaux .....July 1, 1924 to Sept. 1, 1924
Louis C. Loetzer .....Sept. 1, 1924 to Aug. 1, 1925
Wayne A. McNees .....June 1, 1927 to Sept. 1, 1927

TABLE II

INVENTORY OF MONT ALTO FOREST TREE NURSERY
1904

SPECIES	AGE (Years)	AVERAGE HEIGHT (Inches)	NUMBER OF TREES
Red Oak	1	12	20
Chestnut oak	1	10	650
White oak	2	6	420
Red ash	1	14	5,350
Horse chestnut	1	9	390
Locust	1	25	510
Chestnut	1	12	745
Yellow pine	1	1½	1,500
Douglas fir	1	2½	5,575
Red spruce	2	½	3.000
Eastern catalpa (not transplanted)	2	30	485
Eastern catalpa (transplanted)	(1–1)	46	420
Western catalpa (transplanted)	(1–0)	10	4,720
Western catalpa (not transplanted	1	30	17,000
White pine	2	3 to 5	2,400
White pine	2	3	1,500
White pine	2	5	71,400
White pine	1	2	75,000
Total number of trees in nursery			191,085

TABLE III

INVENTORY OF MONT ALTO FOREST TREE NURSERY
November 1, 1907

SPECIES	AGE (Years)	NUMBER OF TREES
White ash	1	23,198
Common locust	1	1,300
Catalpa (cigar tree)	1	2,450
Persimmon	1	6,000
Chestnut oak	1	369
Shag-bark hickory	1	635
Pignut hickory	1	2,950
Black walnut	1	2,567
Tulip tree	1	500
European larch	1	53,600
White pine	1	688,000
White pine	2	189,000
White pine	(Transplants)	9,000
Scotch pine	1	50,000
Western yellow pine	1	500
Norway spruce	2	90,000
Norway spruce	3	73
Balsam fir	1	80,000
Total number of trees in nursery		1,200,142

TABLE IV

INVENTORY OF MONT ALTO FOREST TREE NURSERY
1913

SPECIES	AGE (*Years*)	NUMBER OF TREES
Hardwoods suitable for planting in 1914:		
Black walnut	1	15,000
White oak	1	25,000
Black walnut	(1–1)	3,000
Sycamore	2	3,000
Conifers suitable for planting in 1914:		
European larch	2	3,500
Scotch pine	2	2,000
Norway spruce	(1–2)	2,000
White pine	(1–2)	2,000
Douglas fir	2	10,000
White pine	2	1,000,000
Seedlings and transplants suitable for planting after 1914:		
Norway spruce	1	250,000
Norway spruce	(1–1)	4,000
White pine	1	400,000
White pine	2	100,000
White pine	(1–1)	1,000
European larch	1	30,000
Total number of trees in nursery		1,850,500

TABLE V

INVENTORY OF MONT ALTO FOREST TREE NURSERY
September 5, 1922

SPECIES (*Conifers*)	AGE (*Years*)	AVERAGE HEIGHT (*Inches*)	NUMBER OF TREES
Seedlings:			
White pine	1	2½	1,162,600
White pine	2	5 to 7	970,000
White pine	3	7	123,000
Red pine	1	2	216,000
Shortleaf pine	1	2	450,000
Shortleaf pine	2	6	62,000
Pitch pine	1	2½	220,000
Pitch pine	2	6½	97,000
Jersey pine	1	4	85,000
Jersey pine	2	7	16,000
Scotch pine	1	2½	140,000
Scotch pine	2	5½	278,000
Table mountain pine	1	4	100,000
Banks pine	1	4	535,000
Japanese red pine	2	8	210,000
Japanese black pine	2	4 to 8	290,000
Chinese red pine	1	2	30,000
Austrian pine	1	3	130,000
Western yellow pine	1	3	13,300
Norway spruce	1	2	430,000
Norway spruce	2	5½	575,000
Norway spruce	3	7	659,000
White spruce	2	3	260,000
European larch	1	3	180,000
European larch	2	15	83,000
Japanese larch	1	4	100,000
Japanese larch	2	18	22,000
American arborvitae	1	2	36,200
Transplants:			
White pine	(3-0)	5	4,000
Norway spruce	(3-0)	3	4,300
Norway spruce	(2-1)	3½	4,140
Norway spruce	(2-5-3)	18	3,250
Total number of conifers			7,488,190
SPECIES (*Hardwoods*)			
White ash	2	36	4,000
Green ash	1	15	246,000
Rock oak	1	7	194,000
Red oak	1	7½	120,000
Black locust	1	30	50,000
Black walnut	1	18	10,000
American elm	1	8	58,600
Oriental Sycamore	1	1	22,500
Sugar maple	1 and 2	12	27,500
Basket willow	(Cuttings)	10	100,000
Total number of hardwoods			833,100
Total number * of conifers and hardwoods			8,321,290

*In addition to the trees listed in the above table, the miscellaneous experimental species given in Table VI were also growing in the Mont Alto Nursery in 1922.

TABLE VI

MISCELLANEOUS TREES GROWN FOR EXPERIMENTAL PURPOSES IN THE MONT ALTO FOREST TREE NURSERY IN 1922

SPECIES	AGE *(Years)*	AVERAGE HEIGHT *(Inches)*	RESULTS AND PROSPECTS
American nut pine	1	2	Unsuitable
Loblolly pine	1	6	Not entirely hardy
Hemlock	2	4	Excellent
Western larch	1	1½	Unsuitable
European silver fir	3	3½	Injured by heat
Spanish fir	1	1½	Slow in growth
Balsam fir	1	½	Slow in growth
Lawson cypress	1	2	Not winter hardy
Bald cypress	1	15	Not entirely hardy
Ginkgo	3	18	Unpromising
Korean white pine	(2-2)	3½	Unsuitable
Douglas fir	(3-2-2)	12	Injured by spring frost
Engelmann spruce	(2-2)	3	Unsuitable
Colorado blue spruce	(3-3-1)	9	Very slow grower
Cottonwood	(Cuttings)	—	Requires good soil
Scarlet oak	1	7	Very good
Pin oak	1	7	Good
White oak	1	5	Excellent
Honey locust	1	9	Injured by game
California walnut	1	18	Unsuitable
Hardy catalpa	1	18	Requires good soil
Japanese catalpa	1	15	Unpromising
Red maple	2	18	Unpromising
Japanese scarlet maple	1	4	Unsuitable
Sycamore maple	1	10	Promising
English maple	3	8	Unsuitable
Ash-leaved maple	2	36	Good
Tulip poplar	1	5	Excellent
Wild black cherry	1	7	Good
Japanese empress tree	2	24	Unsuitable
Pecan hickory	1	6	Unpromising
Bitternut hickory	2	6	Unimportant
White mulberry	2	6	Requires good soil
Basswood	1	10	Requires good soil
Kentucky coffee tree	2	24	Requires good soil
Ohio buckeye	1	8	Unimportant
Chinese varnish tree	1	8	Unpromising
Sycamore	2	48	Requires good soil
Chile beech	1	12	Not hardy
Red-bud	2	24	Unimportant
Spanish or southern red oak	2	6	Unpromising
Persimmon	2	12	Unimportant

TABLE VII

INVENTORY OF MONT ALTO FOREST TREE NURSERY
September 13, 1928

SPECIES	AGE *(Years)*	AVERAGE HEIGHT *(Inches)*	NUMBER OF TREES
Trees Large Enough for Shipment:			
White pine	4	10	30,000
White pine	3	8	170,000
Red pine	3	8	575,000
Scotch pine	3	10	300,000
Scotch pine	2	7	170,000
Banks pine	2	—	30,000
Austrian pine	2	7	15,000
Japanese red pine	2	7	27,000
Corsican pine	2	8	6,000
Norway spruce	3	8	250,000
Japanese larch	3	—	90,000
Japanese larch	2	—	60,000
Red pine	(2-2)	10	4,000
White cedar	3	7	3,000
White ash	2	24	100,000
Black walnut	1	14	2,400
English white oak	2	14	400
Tulip poplar	2	18	18,000
Red oak	1	10	500
Total number of trees large enough for shipment			1,851,300
Trees Too Small for Shipment:			
White pine	2	3½	590,000
White pine	1	1¼	1,000,000
Norway spruce	2	4	70,000
Norway spruce	1	1	650,000
Red pine	2	2½	320,000
Red pine	1	1	1,900,000
Scotch pine	1	1½	325,000
Western cedar	1	1	15,000
Japanese larch	—	—	30,000
Pitch pine	1	2	500,000
Shortleaf pine	1	2	100,000
Total number of trees too small for shipment			5,500,000
Total inventory			7,351,300

THE DEER PROBLEM

IN THE

FORESTS OF PENNSYLVANIA

By

Henry E. Clepper

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Bulletin 50

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS

LEWIS E. STALEY, *Secretary*
Harrisburg
1931

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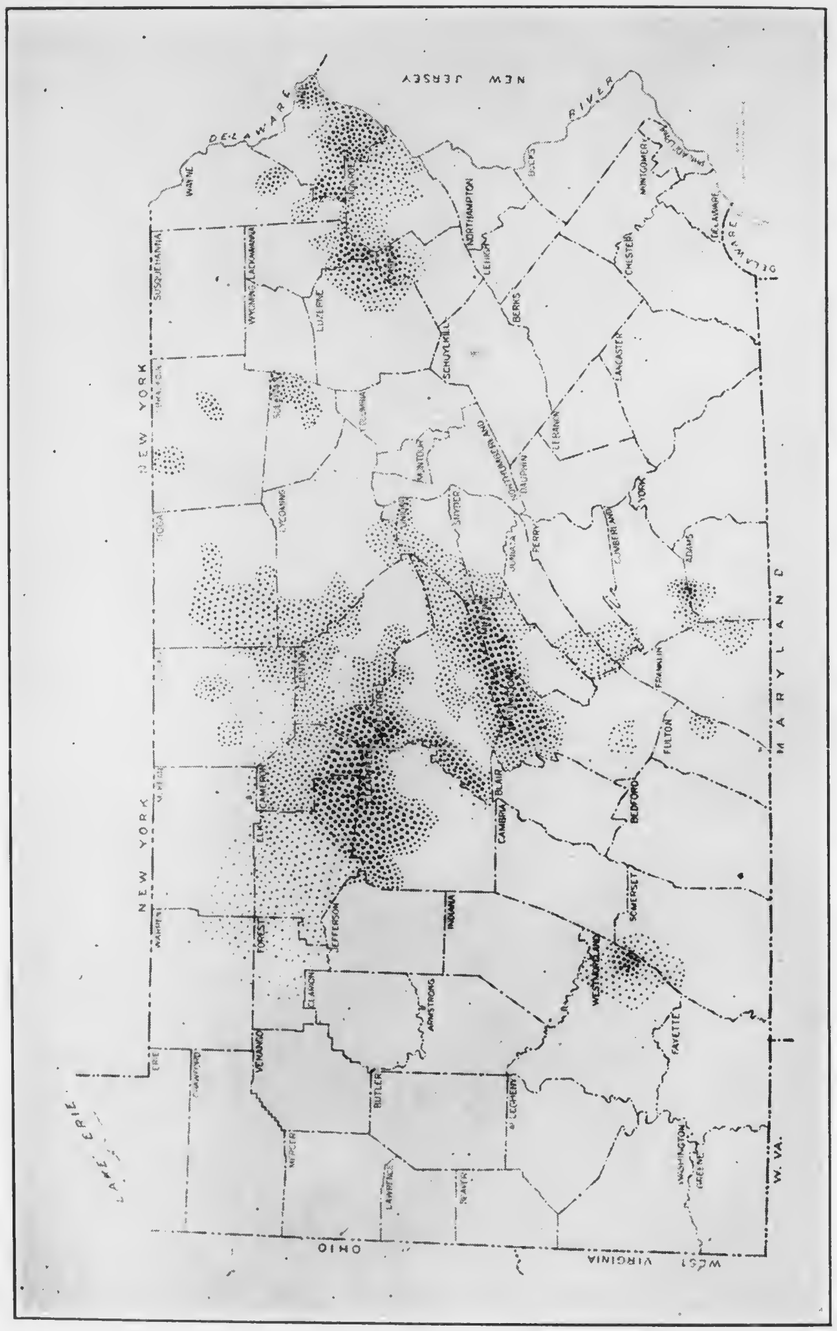

The Extent of Deer Damage to Forests in Pennsylvania. Damage Is Greatest Where Shading Is Heaviest. The Lightly Shaded Areas Indicate Where Deer Damage Is Now Less Extensive but May Soon Become Serious.

THE DEER PROBLEM
IN THE
FORESTS OF PENNSYLVANIA

By

Henry E. Clepper

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Bulletin 50

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF FORESTS AND WATERS
Lewis E. Staley, *Secretary*
Harrisburg
1931

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THE DEER PROBLEM IN THE FORESTS OF PENNSYLVANIA

By HENRY E. CLEPPER

Dr. Joseph T. Rothrock, commonly known as the Father of Pennsylvania Forestry, recommended more than thirty years ago that the Commonwealth purchase forest land not only for the production of wood, but also to control floods, to make available to the public health-giving environment, and to assure outdoor recreation to all citizens of the Commonwealth. The State Forests of Pennsylvania on January 1, 1931, contained 1,558,167 acres. The State Game lands total 211,586 acres.

Pennsylvania has always been known as a heavily forested state abounding in wild life. Before the coming of the white man its woods were the natural habitat of game animals, such as deer, elk, bison, bear, and moose, and predatory animals, such as the wolf, panther, wild cat, and Canada lynx. Although food supplies were plentiful, the game animals mentioned never became overabundant because the predatory species kept them killed off. The moose began to disappear about the time the earliest travellers visited northern Pennsylvania. Extensive and rapid settling contributed greatly to the further reduction of game animals until, about the middle of the past century, the big game species were definitely headed toward extinction. Elk and bison had disappeared.

During the period between the time of the Civil War and the beginning of the present century deer also began to decrease in numbers. Forty years ago deer had become so scarce in Pennsylvania that it was an extremely rare occurrence for one to be seen in its native environment *(13)*. Several causes contributed to the partial extermination of the deer; probably the greatest contributing factors were lack of hunting restrictions, excessive forest exploitation, and destructive forest fires.

HISTORY OF THE DEER PROBLEM IN PENNSYLVANIA

The Pennsylvania Board of Game Commissioners was appointed in 1896. The following year the use of hounds in deer hunting was forbidden and later market hunting was prohibited. The first game refuge law of Pennsylvania, passed in 1905, provided sanctuaries where deer could propogate and thrive without molestation, which practically insured that the deer would never again approach extermination, at least from the causes previously mentioned. The so-called "buck law"

was enacted in 1907, and subsequent acts contributed enormously to insure an increase of the deer herd.

For more than twenty years a primary interest of those agencies engaged in game conservation in Pennsylvania was directed toward an increase in the buck population. The female deer, which naturally increased in population as the bucks increased, began at least fifteen years ago to multiply in great numbers. Thus, it followed that the next problem in the management of the deer in Pennsylvania became one of how to control the deer herd rather than how to increase it.

It was not until about fifteen years ago that the State Forests became widely popular for hunting. The rapidly mounting mileage of hard surfaced highways in Pennsylvania and the increasing use of the automobile made the forests of Pennsylvania accessible for hunting to thousands who ordinarily had not previously enjoyed them. This growing army of hunters, many of whom were desirous of shooting big game, naturally led a justifiable demand for an adequate supply of deer.

About 1915 a few complaints were made by orchardists and farmers that their crops, and therefore their livelihood, were suffering as a result of an overabundance of deer. Injury to agricultural crops increased though subsequent legislation and administrative regulations attempted to reduce the damage. Then beginning about 1922, various foresters in Pennsylvania began to observe in many places, especially in State Forests where the deer population was large, that the forest vegetation, both of native and artificial establishment, was suffering also. Forest tree plantations in Franklin, Union, Centre, Huntingdon, Clinton, Elk, Clearfield, and Pike Counties were not only being damaged, but were being destroyed, by deer. Many plantations that had failed owing to deer damage and destruction were replanted. The browsing of the deer, however, continued and after several additional unsuccessful attempts to establish forest tree plantations where large deer herds were present, it was found that the damage had attained such proportions that it was no longer practicable to plant trees in these locations. Unfortunately, deer damage within the State Forests was extensive on some of the large, severely burned areas that could not be depended upon to reproduce naturally with satisfactory growths of timber.

Investigations made in the winter of 1925-26 for the Board of Game Commissioners by Forester James N. Morton in Franklin, Cumberland, and Huntingdon Counties disclosed the fact that there the forests were overstocked with deer. Damage to natural and artificial forest regeneration was noted as well as the fact that the laurel and rhododendron, which are not considered good food species for deer, were practically destroyed in many places. Thus at least five years ago the Pennsylvania Department of Forests and Waters and the Board of Game Commis-

FIGURE 1. *Waste Lands Kept Unproductive by Deer Browsing. Large Areas That Cannot Be Depended Upon to Reproduce Naturally With Satisfactory Growths of Timber Are Kept Unproductive Because the Deer Prohibit Reforestation.*

FIGURE 2. *Excessive Cropping of Planted Larch Trees. This Species Frequently Is Damaged by Deer Browsing to the Extent of 75% of the Number of Trees Planted.*

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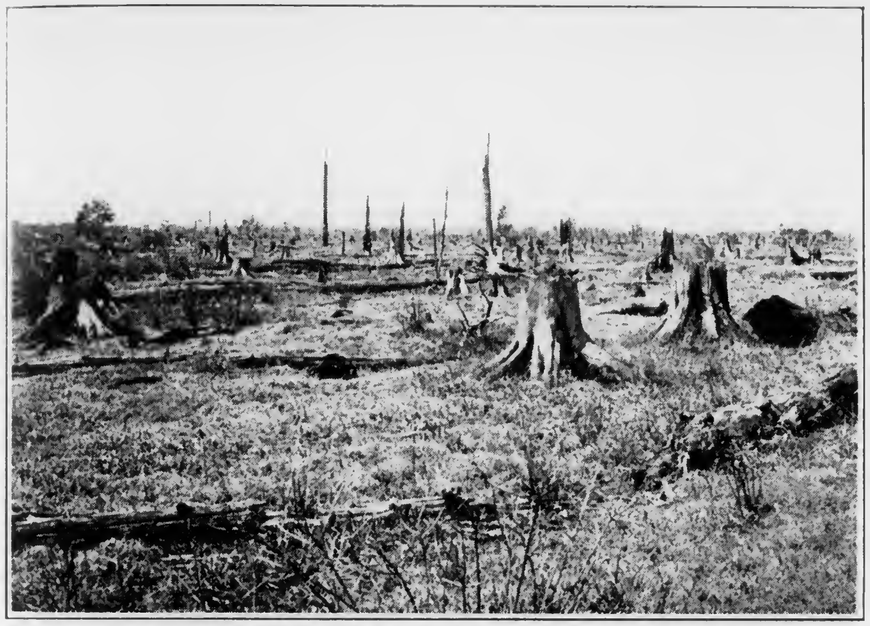

FIGURE 1. *Waste Lands Kept Unproductive by Deer Browsing. Large Areas That Cannot Be Depended Upon to Reproduce Naturally With Satisfactory Growths of Timber Are Kept Unproductive Because the Deer Prohibit Reforestation.*

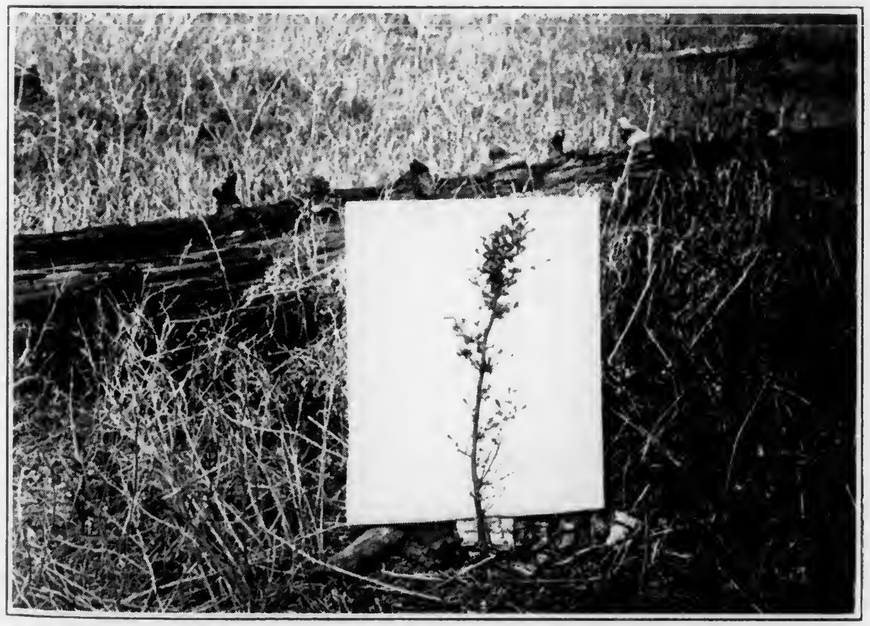

FIGURE 2. *Excessive Cropping of Planted Larch Trees. This Species Frequently Is Damaged by Deer Browsing to the Extent of 75% of the Number of Trees Planted.*

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FIGURE 3. *Scotch Pines, Less Than Eight Inches in Height (from Root Collar to Tips), Planted Six Years and Cropped Back Annually by Deer. Deer Browsing Prohibits the Reforestation of Thousands of Acres of Idle Land.*

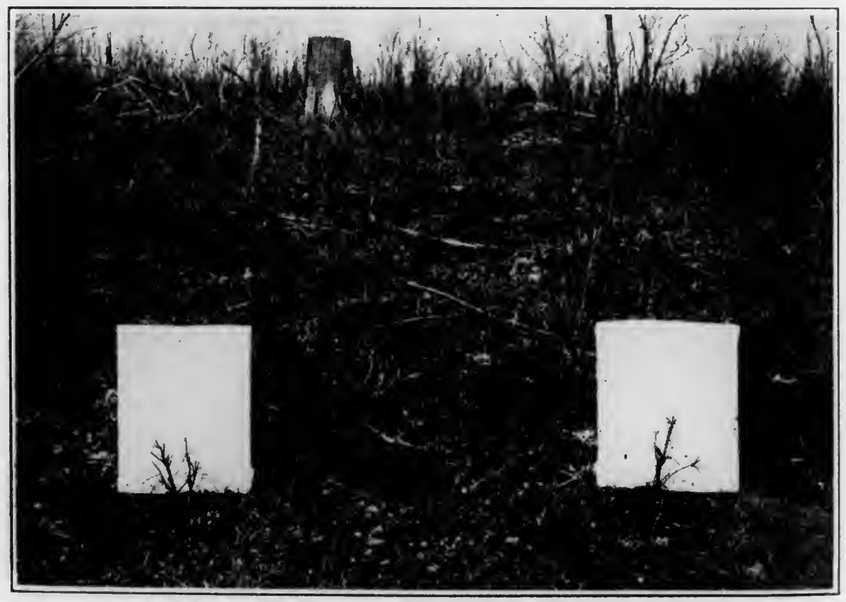

FIGURE 4. *Planted Scotch Pine Severely Browsed by Deer. The Remains of A Scotch Pine Plantation, Showing the Severe Cropping of the Planted Trees by Deer.*

sioners, the two agencies most greatly concerned with the problem, had obtained information, independently acquired, that deer damage to forests was becoming serious.

THE DEER SITUATION IN THE FORESTS OF CENTRAL PENNSYLVANIA

What is perhaps the most outstanding example of deer damage to forest tree growth in Pennsylvania is found in Clearfield County, and

FIGURE 5. *A Young Scotch Pine Tree, Defoliated and Nearly Dead as a Result of Deer Browsing. Frequently Entire Plantations Covering Hundreds of Acres Are Completely Destroyed.*

in southern Elk and Cameron Counties. Throughout this plateau grew extensive forests of white pine and hemlock. Following lumbering operations in this section, which were practically completed by the beginning of the present century, forest fires burned through the inflammable slashings and destroyed all valuable tree growth.

There are now many areas which have been untouched by fire for twenty, twenty-five, and thirty years, and in the course of nature these

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areas should contain at least partially stocked second growth forest. Much of this land, however, can be described as a barren, for no timber crop has become established with the exception of the so-called weed species, fire cherry and aspen. Areas in the State Forest, which even as late as fifteen years ago contained a ground cover of grass, weeds, briars, and scrub growth, are now devoid of this type of vegetation.

District Forester William F. Dague, Clearfield, Pa., has observed areas which even ten years ago had an almost impenetrable brush cover. During the past decade this growth has been so heavily browsed by deer that it may be said there is practically no undergrowth whatever. Although the soil is deep and moist, of a sandy loam texture and highly

FIGURE 6. *Oak Sprouts Severely Damaged by Deer Browsing. A Study Plot Laid Out in this Clear-cut Area Revealed the Fact that 51% of the Sprout Growth Has Been Severely Browsed by Deer and 41% Has Been Slightly Eaten. Brush Valley, Miles Township, Centre County.*

satisfactory for growing trees, it is District Forester Dague's opinion that the natural reforestation of this region will require one hundred years if present conditions persist.

It has been estimated that there are 15,000 acres in the State Forest in Clearfield County that under present conditions would have to be planted to restore an adequate growth of timber *(8)*. At least ten and probably twelve million trees would be required. Under the conditions obtaining in Clearfield County at the present time, and in view of the fact that the present size of the deer herd prohibits a successful establishment of these plantations, it is apparent that this reforestation

project must be abandoned unless satisfactory solutions can be found either to reduce the deer population or to protect the planted trees. Plantations established during the last seven years in this locality have been entirely destroyed by deer.

For example, in 1924, 1925, and 1926, a total of 197,000 forest trees was planted in Lawrence Township, Clearfield County, in the State Forest. The species were red pine, shortleaf pine, Banks pine, pitch pine, Scotch pine, Japanese larch, and European larch. Careful inspection of many of the smallest trees indicated that their terminal branches had been nipped by deer even before the new growth had started. Practically all trees growing in open spaces were severely browsed or killed. Those planted among briars and other debris were browsed least, but these constituted such a small proportion of the total as to be negligible. The trees have suffered so severely from year to year and their numbers have so decreased that the entire plantation is a failure.

THE DEER SITUATION IN OTHER SECTIONS OF PENNSYLVANIA

Lest it be supposed that deer damage is excessive only in a few limited regions of central Pennsylvania, the scope of the problem may be better understood if a few additional specific instances of large scale damage to forest trees are briefly cited.

In the Mont Alto State Forest in Quincy Township, Franklin County, a total of 29,700 trees was planted in Brandon Hollow in 1925. The species used were shortleaf pine, tulip poplar, Norway spruce, white pine, and larch. Deer browsing on these trees averaged from 60 per cent on the white pines to 75 per cent on the larches and 80 per cent on the shortleaf pines. The entire plantation may be considered a failure with the exception of the white pines, at least half of which may come through.

In the Bald Eagle State Forest in Miles Township, Centre County, 82,500 trees were planted in 1918. The following species were used: white pine, Scotch pine, pitch pine, and Norway spruce. Nearly 80 per cent of the trees have been browsed by deer; their average height when examined was only three feet, whereas they should be at least twelve feet tall at the present time. Another plantation of ten acres established in the spring of 1927 near this site was found upon examination to have 75 per cent of the trees with tops nipped off.

In the Delaware State Forest in Porter Township, Pike County, a plantation of 60,000 white pines, established in 1919, has been totally exterminated by the deer. Other reforestation projects, both of seeding and planting origin, have failed because of excessive deer cropping and rubbing of the trees *(9)*.

In East Keating Township, Clinton County, an area, which had been lumbered and then severely burned by repeated fires, was planted in 1928 with 150,000 white pines, red pines, pitch pines, and Norway spruces. The trees were small and many no doubt died, but most were eaten severely by deer. Today practically all the trees have been eaten and killed.

Similarly in the southern part of Cameron County and the southeastern part of Elk County, west of the Susquehanna River, there are approximately 6,000 acres that must be planted to obtain full forest

FIGURE 7. *Oak Sprouts Lightly Damaged by Deer Browsing. An Area With Natural Hardwood Sprouts and Planted White Pine, Following Clear-cutting. The Hardwoods Have Been Browsed More Severely Than the White Pines, but A Satisfactory Growth Should Result Providing Deer Browsing Becomes No Heavier. Adjoining State Game Refuge 1, Noyes Township, Clinton County.*

cover *(8)*. However, the deer have browsed planted trees in this section so heavily during the past ten years that it is reasonable to expect that a reforestation project here would be a failure.

In other State Forests and in privately owned land in central and north-central Pennsylvania there are many thousands of acres that should be reforested if this sub-marginal land is to be put to its highest possible use, which is growing timber. Much of this land consists of abandoned farms and areas where forest fires have prevented satisfactory natural stands. In the course of time areas that have been burned, no matter how severely, may reproduce naturally to some form

of forest cover, but under present conditions there is no assurance that these burned areas will regenerate themselves, in as much as the natural sprout growth is eaten back annually by the deer.

SPECIAL STUDIES OF DEER DAMAGE TO NATURAL REPRODUCTION

It is not sufficient in any study of game management in relation to forested areas merely to say that damage is being done. Throughout widely scattered areas in Pennsylvania careful examinations were made of areas of natural growth in an attempt to determine the present and possible future damage by deer.

Centre County. In the Bald Eagle State Forest District, in Brush Valley, Miles Township, along State Highway Route No. 95, is an area burned by a forest fire in September, 1929. Following the fire the trees were lumbered off in the winter of 1929-1930, which resulted in practically a clear cutting. In the spring of 1930 sprout clumps began to appear. A study plot laid out in this area in September, 1930 revealed the condition as shown in Table I.

TABLE 1.

Condition	Number of Trees Per Acre						
	White Oak	Scarlet Oak	Red Maple	Red Oak	Scrub Oak	Total	Per Cent of Total
Badly browsed	272	80	112		80	544	51
Slightly browsed	48	80	16	32	256	432	41
Not browsed	32				48	80	8
Total	352	160	128	32	384	1,056	100

Table I shows that of a total of 1056 sprout clumps per acre approximately half were severely eaten and about 40 per cent were slightly eaten. Many of those sprouts not touched or only slightly eaten were wholly or partially covered by windrows or brush. The number not eaten at all, when it is considered half of these are scrub oak, may be entirely insufficient to establish naturally a new forest on this area. Observations over a period of several years will be necessary to determine this fact.

Clinton County. In the Sproul State Forest District on the border of Noyes Township and Beech Creek Township, along the Snow Shoe-Renova road, is an area adjoining State Game Refuge 1, which was planted with white pine and later the overtopping hardwood growth was clear cut. The white pine trees have an average height of four feet. A dense hardwood sprout growth has come up with the planted

white pine trees. A study plot laid out in this area in September, 1930, revealed the condition as shown in Table 2.

An examination of Table 2 shows that the planted white pines have suffered considerably less from browsing than the associated hardwoods. Ordinarily the white pines would suffer from browsing nearly as much as the hardwood sprouts, but in this case they have suffered less because the hardwoods have provided an abundance of tender, succulent food more to be desired than the conifers. Contrasting Table No. 1 with Table No. 2, we find that there are three times as many sprout clumps and seedlings in the latter. On this basis it may be estimated that, providing browsing becomes no heavier, there will be sufficient planted and natural growth of good species to provide a satisfactory new growth.

TABLE 2.

Condition	Number of Trees Per Acre				
	White Pine	White Oak	Scarlet Oak	Red Maple	Chestnut
Badly browsed	118	259	142	47	635
Slightly browsed	141	553	70	188	94
Not browsed	799	47	----	23	23
Total	1,058	659	212	258	752

Condition	Number of Trees Per Acre				
	Sassafras	Rock Oak	Scrub Oak	Total	Per Cent of Total
Badly browsed	47	----	47	1,295	39
Slightly browsed	----	47	164	1,057	32
Not browsed	----	----	70	962	29
Total	47	47	281	3,314	100

Sullivan County. In the Wyoming Forest District, along State Highway Route 115, in Shrewsbury Township, is an area, formerly containing a stand of beech, birch, and maple, which had been clear cut. The sprouts on the area are now one and two years old. A study plot was laid out in October, 1930, and revealed the condition as shown in Table 3.

Table No. 3 indicates that deer browsing may take some toll of forest growth without doing damage serious enough to check or jeopardize normal, natural restocking of cut-over lands. The table illustrates a situation common to the locality, namely, that although deer are numerous they are not sufficiently abundant to lack food, and consequently damage to the natural reproduction of beech, birch, and, maple, and associated species is apparently less than in other forest types.

These three study plots indicate how the situation varies from place to place. Tables such as these could be extended indefinitely, although for the purpose of this discussion it is perhaps sufficient to include only these three. Many such plots are being laid out from time to time in Pennsylvania forests in an effort to learn the seasonal feeding habits of deer in various forest types under diverse conditions of forest management.

TABLE 3.

Condition	Number of Trees Per Acre				
	Sugar Maple	Yellow Birch	Fire Cherry	Black Wild Cherry	Beech
Badly browsed	48	16	64	----	----
Slightly browsed	192	32	128	----	16
Not browsed	160	48	288	432	----
Total	400	96	480	432	16

Condition	Number of Trees Per Acre				
	Red Maple	Aspen	Chestnut	Total	Per Cent of Total
Badly browsed	----	16	----	144	8
Slightly browsed	32	64	----	464	24
Not browsed	80	240	48	1,296	68
Total	112	320	48	1,904	100

In the foregoing tables we have confined our investigations to damage to regeneration following fire or some form of cutting. Although the damage done to the understories of forest stands may be, and often is, serious, still in these cases there is no problem presenting itself for immediate solution as there is when the damage is concerned with reproduction on burnt or cut-over lands. When forest stands are present, but of sufficient size to be beyond the reach of the deer, damage done to undergrowth is obviously of less importance than when no forest stands are present and planted natural growth must be depended upon to produce the forests of the future. In the latter instance, the amount of deer damage present becomes of paramount importance not only to forestry practice, but to the welfare of the deer herd, which once having exhausted its food supply may have serious difficulties finding sustenance to carry them throughout the year.

PERMANENT DEER DAMAGE STUDY PLOTS IN PLANTATIONS AND NATURAL REPRODUCTION

Mention was made in Research Circular 3, "Deer Damage to Forest Trees in Pennsylvania," a preliminary study by the Pennsylvania Department of Forests and Waters *(7)*, that twelve study plots were established in six State Forests, in Clearfield, Cumberland, Huntingdon, Pike, Potter, and Clarion Counties. These study areas, started in the Spring of 1929, were established by the Pennsylvania Department of Forests and Waters and the Pennsylvania Board of Game Commissioners cooperating. Each study area consisted of two one-acre plots. One acre of each plot was enclosed with a seven and one-half foot deer-proof fence. The adjoining acre was not fenced. The field work was supervised by Forester James N. Morton of the Board of Game Commissioners and Forester Richard M. May of the Department of Forests and Waters.

Eight of the ten one-acre plots were planted with forest tree seedlings. The same species and the same manner of planting were followed on both the fenced plots and on the unfenced. The remaining two one-acre plots were laid out in natural hardwood growth.

The purpose of the establishment of these plots was to provide the two cooperating agencies with specific and exact information as to just how much damage and what kind of damage are done to planted trees and natural forest growth in widely scattered localities where deer are present. The fact that each plot purposely exposed to unrestricted deer browsing had an adjacent control or check plot provided that there would be removed any possibility of other factors influencing final results. The plots were established in the spring of 1929 and when completed were examined (May, 1929) to determine the percentage of establishment of the trees on both the unfenced plots, where browsing would be unrestricted, and on the fenced or check-plots, where deer could not enter. The next year (1930) after the deer had been given an opportunity to feed on the planted trees, especially over the winter, the plots were reexamined to determine the percentage of trees remaining on the fenced plots as contrasted with the number on the unfenced plots. Thus, it was possible to obtain a fairly accurate answer to the question: "How much and how severely do deer damage planted forest trees?"

Cumberland County. Two adjoining areas, one fenced, of one acre each, were laid out in Cook Township on the north side of the Bendersville road, one-fourth mile east of Pine Grove Furnace. The plots are located on an abandoned field now covered with grass and weeds. The aspect is southerly and the ground level. The sites are classified as Quality I. The two plots were planted with white pine, Scotch pine, and Norway spruce in alternate rows.

FIGURE 8. *The Deer Line Common in Pennsylvania Forests. In Some Regions of Pennsylvania the Deer Have Exhausted the Food Supply to Such an Extent That There Are Deer Lines Through the Forest Showing That They Have Eaten All Vegetation for A Height of Five Feet Above the Ground. Promised Land, Greene Township, Pike County.*

FIGURE 9. *Heavily Deer Browsed Area Showing Complete Exhaustion of Food Supply. A Deer Lick in Foreground. The Deer Have Eaten All Vegetation as High as They Can Reach. Near Lopez, Colley Township, Sullivan County.*

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FIGURE 11. *A Twelve Year Old White Pine, Two and One-half Feet High, Dying as A Result of Deer Browsing. Note How the Tree Becomes Deformed After Repeated Croppings.*

FIGURE 10. *A Young White Oak Three Feet in Height, Killed by Deer, Natural Reproduction is Subject to Extensive and Excessive Deer Browsing in Many Forest Regions of Pennsylvania.*

TABLE 4.

Species	Per Cent of Living Trees						Approximate Per Cent of Loss by Deer
	Fenced Area			Unfenced Area			
	May 21, 1929	Nov. 19, 1929	Nov. 16, 1930	May 21, 1929	Nov. 19, 1929	May 16, 1930	
White Pine	100	88	80	100	81	45	35
Scotch Pine	100	92	89	100	93	55	34
Norway Spruce	100	94	81	100	93	24	57

Table 4, showing the conditions of the plantation on several examinations, indicates that the deer damage has ranged from one-third of the total number of trees for white pine and Scotch pine to one-half for Norway spruce. In brief, any forest tree plantation established here would probably prove a failure.

Clearfield County. Two adjoining areas, one fenced, of one acre each, were laid out on the west side of the Clearfield-Penfield road, in Pine Township, one-fourth mile north of the Clearfield State Forest Tree Nursery. The area is in open brush land and prior to planting was cleared of all brush and debris. The species planted were red pine transplants, Japanese larch, Scotch pine, and white spruce in mixture. When examined on May 22, 1929, the establishment was 95 per cent on the fenced acre and 97 per cent on the unfenced acre. When reexamined April 30, 1930, the trees on the fenced acre had been damaged to the extent of 10 per cent by frost and winter-kill. On the unfenced acre 90 per cent of the trees were dead or missing, apparently as a result of deer damage. The remaining 10 per cent, principally Japanese larch, had been nipped by deer but showed signs of life. In addition to the planted trees the native sprout growth of maple, chestnut, and other hardwoods on, and adjoining, the area showed considerable deer damage. Reforestation is hopeless in this locality under present conditions.

Pike County. Two adjoining areas, one fenced, were laid out in Porter Township on the Whittaker Place, on an abandoned field covered with grass and weeds. Red pine, Japanese larch, white pine, Norway spruce, Scotch pine, and white spruce were planted.

The establishment on the fenced plot at the time of examination, May 23, 1929, was 77 per cent and on the unfenced plot 76 per cent. Not all of the larch survived shipment owing to the lateness of their lifting from the nursery. When examined July 10, 1930, the fenced plot had 76 per cent of the trees living. On the unfenced plot careful examination revealed only 41 living trees, or 6 per cent, and these

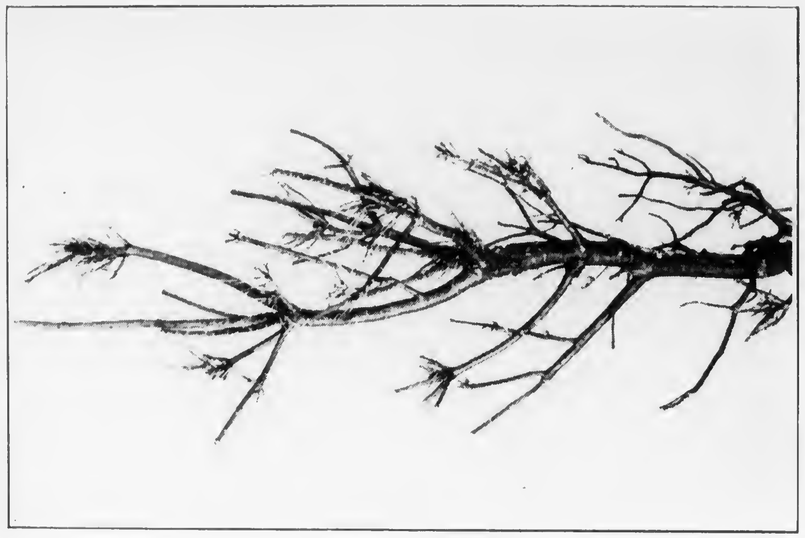

FIGURE 11. *A Twelve Year Old White Pine, Two and One-half Feet High, Dying as A Result of Deer Browsing. Note How the Tree Recovers Is Secured After Repeated Croppings.*

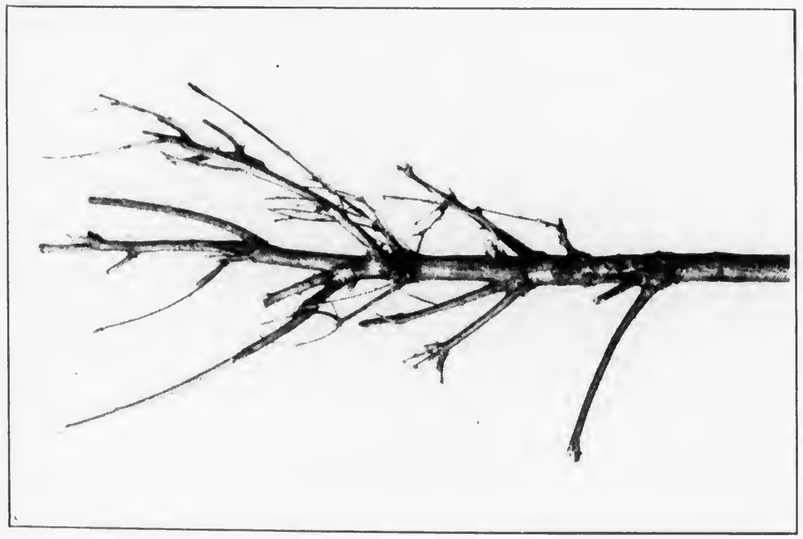

FIGURE 10. *A Young White Oak Three Feet in Height, Killed by Deer. Natural Reproduction is Subject to Extensive and Excessive Deer Depredation in Young Forest Regions of Pennsylvania.*

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The establishment on the fenced plot at the time of examination, May 23, 1929, was 77 per cent and on the unfenced plot 76 per cent. Not all of the larch survived shipment owing to the lateness of their lifting from the nursery. When examined July 10, 1930, the fenced plot had 76 per cent of the trees living. On the unfenced plot careful examination revealed only 41 living trees, or 6 per cent, and these

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had all been nipped by deer. Further reforesation is out of the question here.

Huntingdon County. Two adjoining areas, one fenced, of one acre each, were laid out in Logan Township on the McGuire Farm at the foot of Round Top Mountain, on an abandoned field covered with grass and dewberry vines. The following species were planted, mixed at random: white pine, red pine, Banks pine, Austrian pine, Scotch pine, Japanese larch, and Norway spruce.

When examined in the latter part of May, 1929, the fenced plot had an establishment of 98 per cent, and the unfenced plot 90 per cent. Reexamination on May 8, 1930, showed that on the fenced plot 70 per cent of the trees were still living, but on the unfenced plot practically all the trees were dead or missing as a result of deer damage. Only a few browsed Japanese larch and pines were still present. The deer herd prohibits further reforestation.

Potter County. Two adjoining areas, one fenced, of one acre each, were laid out on the north slope of Hockney Hollow in Summit Township, in a young stand of hardwoods composed of the following species: sugar maple, black and yellow birch, fire cherry, sumac, beech, hemlock, ash, and aspen, with many clumps of mountain laurel. Associated species are blackberry, partridge berry, bracken fern, and lycopodium. The stand is made up as follows:

Seedlings	45 per cent	Large Saplings .	15 per cent
Small Saplings .	30 per cent	Small Poles	10 per cent

When the plots were established a few seedlings and blackberry bushes showed evidence of deer browsing.

When examined May 26, 1930, deer damage was found centered primarily on sugar maple, which showed 38 per cent of the growth of this species on the unfenced plot browsed by deer. Evidence of deer browsing was also noted on fire cherry, but the other species on the unfenced acre have been practically untouched. On the cleared strips around the two plots deer browsing was evident on all species, but the damage had been slight. Bracken fern and sumac had their tips nipped.

The condition of the unfenced acre contrasted with the fenced plot indicates that the deer here offer no particularly serious problem.

Clarion County. Two adjoining areas, one fenced, of one acre each, were laid out in a natural stand in Farmington Township, one mile south-east of the village of Crown. The species present are scarlet oak, scrub oak, large toothed aspen, pitch pine, sweet fern, and bracken fern. Forest fire has not burned in this site for many years, and the scrub oak, consequently, is being crowded out by the larger, more

valuable species. Evidence of deer cropping may be seen, but no damage is being done.

This study plot is valuable in that it will provide a record of conditions in an area where deer are increasing in numbers, but where deer damage is not yet perceptible. It will furthermore be possible to determine, by annual examinations, how many years elapse between the period when deer crop tree growth without doing damage and the period when the damage becomes serious.

COMMENTS ON THE FEEDING HABITS OF DEER

The life habits of the deer have been discussed in many books on natural history, but in as much as the deer in Pennsylvania have within recent years apparently undergone important changes in order to adapt themselves to changing conditions it may not be amiss to describe briefly their feeding habits.

There is no question but that the natural growth in the forests of Pennsylvania provides an excellent and balanced food diet for deer. Furthermore, Pennsylvania forests are capable of supplying an adequate food supply if the herd remains at an optimum population and does not increase beyond the capacity of the natural growth to provide food.

In many sections of Pennsylvania where deer are too abundant they exhaust their supply of summer food early and are forced to begin eating their winter food before the normal time, consequently many of them are unable to find food at all during the later winter months and many die of starvation, or succumb to undernourishment which permits access of fatal diseases *(14)*. The scarcity of food in many places in Pennsylvania has become so acute that the deer are forced to skin off the bark of the sumac, mountain ash, and other species.

Whereas deer appear naturally to be willing to try out new kinds of food, on the other hand they are very loath to seek out new feeding grounds. In other words, a deer herd, which to begin with may be entirely too large for the available growth in a region adequately to support it, will remain and live in that region on a starvation diet rather than seek out new feeding areas even within a few miles of their home range. An example of this condition may be found in the Diamond Valley, Huntingdon County, where the deer have congregated in certain regions of an extensive tract of State Forest. Here they have practically exhausted the food supply to such an extent that there is a clearly marked deer line approximately six feet above the ground, showing that the deer have eaten all vegetation as high as they can reach. Adjoining tracts which provide almost identical kinds and conditions of food have been apparently browsed so little that the growth is barely touched.

Another phase of the food problem affected by an apparent change in their life habits is brought about when deer give birth to fawns late in the summer. Ordinarily a female deer gives birth to one or two off-spring in the early part of May. It has been observed, however, that when fawn are born late in the summer, as now frequently happens, these young are unable to attain adequate growth before the winter months begin. Consequently as food becomes scarce, these young are among the first to suffer, and the mortality among them is apt to be high.

Food of Deer. A ruminant and browsing animal, the deer feeds entirely upon vegetable matter. The leaves, buds, and tender twigs of shrubs and trees provide its regular diet and the bulk of its food, especially during the spring, summer, and fall seasons. In the oak-chestnut forest type, where there are large trees, nuts provide good food in the fall. Until the disappearance of the chestnut from the forests of Pennsylvania, as a result of the chestnut blight, deer depended on the nuts of this tree for food. The oaks are now the principal species providing deer food in the form of nuts. When other food is scarce in winter they will eat the leaves and twigs of common mountain laurel and rhododendron, and even bark, which they ordinarily apparently dislike. Deer apparently are able to subsist on food which is poisonous and which has a toxic effect on other animals *(4)*.

An observation made by practically all of the foresters of the Pennsylvania Department of Forests and Waters, as well as by many others, is that the deer appear to be inclined to eat any and all kinds of available vegetable food and will try anything new. This fact has been proven in hundreds of cases where foreign and exotic species of trees have been planted in the State Forests of Pennsylvania for experimental purposes, and have been eaten wholly or in part.

During the course of this study an attempt was made to tabulate the perennial plants, with particular reference to tree and shrub growth, which constitute the bulk of deer food. Food supplies were examined all over Pennsylvania. It will be noted from the following list that practically all the common trees and shrubs of Pennsylvania were observed to have been browsed by the deer. Because the plant food of deer is so extremely varied, it is the belief of the author that practically no woody plants common to Pennsylvania are rejected as food by deer. However, observations made throughout the State indicate that a few woody plants are used for food only when others are not available. Norway spruce and white spruce, for example, are frequently found only very lightly browsed, probably because the deer dislike contact with their very stiff, short needles.

While no special investigation of the agricultural crop foods of deer was contemplated in the course of this study, data regarding this type

of food were obtained through observation and by questioning farmers, orchardists, and game protectors throughout the State. Deer will eat nearly all kinds of agricultural produce, including both cereal and garden crops. They seem particularly to like buckwheat, oats, and corn, and will also eat potato and beet tops, and cabbage, bean, pea, carrot, lettuce, and celery plants. Apples and other fruits are eaten as well as the fruit trees. Grape and berry vines and their fruits are also taken.

There follows a tabulated list of the woody plant food of deer. An attempt has been made to indicate from observation the portion of the plants browsed, nipped, or cropped. Where an interrogation point follows the name of a plant it indicates that browsing has been reported but not verified. Browsing has been listed as heavy or light, depending upon the severity of the damage. The records further show whether the browsing had been observed on natural growth or on planted species, or on both. In compiling this list the author makes no claim as to its comprehensiveness, but merely exhibits it to demonstrate the varied food sources of deer in Pennsylvania.

TABLE 5. WOODY PLANTS BROWSED BY DEER

Species	Buds	Leaves	Branches	Fruit	Bark	Browsing	Natural Growth	Planted
Banks Pine		x				Light		x
Austrian Pine	x	x	x			Heavy		x
Chinese Red Pine	x	x				Light		x
Red Pine	x	x				Heavy		x
Pitch Pine	x	x	x			Heavy	x	x
Scrub Pine	x	x				Light	x	
Shortleaf Pine	x	x	x			Heavy		x
White Pine	x	x	x			Heavy	x	x
American Larch		x				Light	x	
European Larch	x	x	x			Heavy		x
Japanese Larch	x	x	x			Heavy		x
Colorado Blue Spruce	x					Light		x
Red Spruce	x					Light		x
Norway Spruce	x	x	x			Light		x
White Spruce	x					Light		x
Hemlock	x	x	x		x	Heavy	x	x
Douglas Fir	x	x				Heavy		x
Balsam Fir	x					Light	x	x
American Arbor Vitae	x	x	x			Heavy		x
Oriental Arbor Vitae	x	x				Light		x
Giant Arbor Vitae	x					Light		x
Hinoki Cedar	x					Light		x
Sawara Cedar	x					Light		x
White Cedar	x					Light		x
Juniper	x	x	x			Light	x	
Red Cedar	x	x	x			Light	x	
Sassafras	x	x	x		x	Heavy	x	
Spice Bush	x					Light	x	
Gooseberry	x	x	x	x		Heavy	x	
Wild Currant	x	x	x	x		Heavy	x	

TABLE 5. WOODY PLANTS BROWSED BY DEER—Continued

Species	Buds	Leaves	Branches	Fruit	Bark	Browsing	Natural Growth	Planted
Witch Hazel	X	X	X			Heavy	X	
Sycamore	?	?	?			Light	X	
Thorn	X					Light	X	
Chokeberry	?					Light	X	
Crab Apple	X	X	X	X		Light	X	
Apple	X	X	X	X	X	Heavy		X
Mountain Ash	X	X		?	X	Heavy	X	
Service Berry	?					Light	X	
Raspberry		X	X	X		Light	X	
Blackberry		X	X	X		Light	X	
Sweetbrier	X	X	X			Light	X	
Choke Cherry	?	?	?	?		Light	X	
Wild Black Cherry	X	X		?		Heavy	X	
Locust	X	?				Light	X	X
Ailanthus	X				X	Light	X	
Sumac	X	X	X	X	X	Heavy	X	
Winterberry	X	X				Light	X	
Bittersweet	X	X	X	?		Light	X	
Red Maple	X	X	X			Heavy	X	
Sugar Maple	X	X	X			Heavy	X	X
Stripped Maple	X	X	X			Heavy	X	
Wild Grape	X	X	X	X		Heavy	X	
Virginia Creeper		X				Light	X	
Basswood	X	X	X			Heavy	X	
Devil's Club	X	X	X		X	Heavy	X	
Dogwood	X	X	X			Heavy	X	
Black Gum	X	X				Light	X	
Willows	X		X			Heavy	X	
Large-toothed Aspen	X	X	X		X	Heavy	X	
Quaking aspen	X	X	X		X	Heavy	X	
Sweet Fern	X	X	X			Heavy	X	
Black Walnut	X					Light		X
Butternut	X					Light	X	
Hickories	X					Light	X	
Black Birch	X	X	X			Light	X	
Yellow Birch	X	X	X			Light	X	
Gray Birch	X	X				Light	X	
River Birch	X					Light	X	
Canoe Birch	X					Light	X	
Smooth Alder	X	X	X		X	Heavy	X	
American Hornbeam	X					Light	X	
American Hop Hornbeam	X					Light	X	
Hazlenut	X					Light	X	
Beech	X	X	X		X	Heavy	X	
Chestnut	X	X	X	X		Heavy	X	
Chinquapin	X	X		X		Light	X	
Chinese Chestnut	X	X				Light		X
White Oak	X	X	X	X		Heavy	X	
Scrub Chestnut Oak	X			X		Light	X	
Chestnut Oak	X	X	X	X		Heavy	X	
Burr Oak	X		X			Light		X
Red Oak	X	X		X		Light	X	X
Pin Oak	X			X		Light	X	
Scarlet Oak	X	X	X	X		Heavy	X	
Black Oak	X	X	X	X		Light	X	
Scrub Oak	X	X	X	X		Heavy	X	
American Elm	X	X				Heavy		X
Hackberry	?					Light	X	
Mulberry	?					Light	X	
Osage Orange	?					Light		X

TABLE 5. WOODY PLANTS BROWSED BY DEER—Concluded

Species	Buds	Leaves	Branches	Fruit	Bark	Browsing	Natural Growth	Planted
Tulip Tree	X	X	X		X	Light	X	X
Rhododendron	X	X	X			Heavy	X	
Mountain Laurel	X	X	X			Heavy	X	
Sheep Laurel	X	X	X			Light	X	
Arbutus	X	X	X	X		Heavy	X	
Teaberry	X	X	X	X		Heavy	X	
Huckleberry	X	X		X		Heavy	X	
Deerberry	X	X	X	X		Heavy	X	
Blueberry	X	X	X	X		Heavy	X	
White Ash	X	X	X			Heavy	X	X
Black Ash	X	X				Light	X	
Red Ash	X					Light	X	
Green Ash	X					Light		X
Catalpa	X					Light		X
Honeysuckle	X	X	X			Heavy	X	
Sweet Viburnum	X	X				Heavy	X	
Black Haw	X	X	X	X		Heavy	X	
Elderberry	X	X	X	X		Heavy	X	
Greenbrier	X	X	X			Light	X	
Ground Hemlock (17)	X	X	X	X		Heavy	X	

SPECIAL STUDIES OF FOOD SUPPLIES ON BURNED AREAS

A subject which has led to much discussion, but which has had little investigation, is "What effect does forest fire have on food supplies of deer?" The consensus of opinion among observers is that deer find the sprout growth that follows forest fire highly desirable for food. Superficially, this observation holds true, for careful examination of many burned areas indicates that deer heavily browse the tender leaves, buds, and twigs of the sprout growth that springs up during the first and second year following a fire.

Whether the deer continue to find this growth suitable for food after the third or fourth year is an open question. Likewise it is uncertain whether the deer browse heavily in the new sprout growth, immediately following a fire, because of its succulency or whether they are attracted to it because of the taste of the new growth. Following a forest fire a relatively large amount of calcium, phosphorus, and potash, as well as other minerals, is deposited on the surface of the soil in the form of ashes. These chemical substances combining with water from saline compounds which are drawn into the plants as food. It is logical to assume that the deer find these saline compounds in the plant food palatable. Witness the many examples of complete browsing on areas for a year or two following fires.

"In succeeding years as the compounds are leached out of the soil by rain, the plant food ceases to be palatable to the deer and the burned areas then become less desirable than unburned areas as food sources." This, briefly, is the conclusion reached by George S. Perry,

Research Forester, Pennsylvania Forest Research Institute, following investigations of soil profile and vegetation data on the Mont Alto State Forest.

A newly constructed State Forest road, up the northwestern side of Snowy Mountain in Franklin County, passes for one-half mile through an excellent stand of hardwoods untouched by fire. Then the road enters an area burned in the spring of 1917. Further on is

FIGURE 12. *A Young Chestnut Sprout Severely Browsed by Deer. Chestnut, A Favorite Food of Deer, Is Handicapped in Its Fight for Recovery Against the Chestnut Blight in Many Sections by Excessive Deer Browsing.*

an area where fires have burned at frequent intervals. The road eventually crosses a plateau over which fires have swept severely; the latest burning occurred in May, 1926.

Deer are abundant in this locality. The sites are covered with mixed oak growth and the species present on each are quite similar. Examination of the different sites described indicates that the deer

are highly selective as to their feeding ground. Briefly, the findings are as follows:

1. On the area where fires have never burned almost every leaf has been eaten off the trees and shrubs as high as the deer can reach.

2. On the area burned last in 1917 the browsing has been fairly heavy, though lighter than on the previous one.

FIGURE 13. *A Young Red Maple Sprout Severely Browsed by Deer. In Some State Forests Timber Cutting Operations Cannot Be Carried on Except in the Form of Thinnings. Because the Deer Consume the Natural Reproduction That Is Depended Upon to Produce A Future Timber Crop.*

3. On the area severely burned in 1926 it is difficult to find a single leaf eaten by deer, though droppings and numerous tracks show they take advantage of the shelter provided by the dense brush growth.

This phase of the problem of deer feeding is comparatively new. The chemical compounds available in the soil for plant food un-

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doubtedly exert some influence on the palatibility and desirability of the plants as browse. A study of the relation between chemicals in the soil and browsing by deer is being started at the Greenwood Forest Tree Nursery in Huntingdon County under the supervision of the Pennsylvania Forest Research Institute.

Another observation that indicates the selectivity of deer feeding in relation to burned areas is this: Where mountain laurel is found growing in association with rock oak on sites where no forest fires have burned for at least ten years, the deer have frequently browsed the laurel almost to the point of extinction. On sites where mountain laurel is found growing in association with rock oak and where fires have burned within the past ten years, the laurel is barely touched. The inference is that deer avoid as much as possible feeding on areas after the third year following fire.

There are those who advocate the controlled periodic burning of forests, believing that waning supply of deer food, caused by an overabundance of deer, would thereby be increased. The fallacy and selfishness of this argument are obvious. Granted that the buring of forest cover at times results in a temporary increase of available deer browse, the attendant losses to growing timber and to small game, such as wild turkey, grouse, rabbits, and squirrels, would be all out of proportion to the meager benefit to the deer herd. Any system of management that sacrifices timber for game, or vice versa, or that discriminates against one type of hunter for the benefit of another, is indefensible *(14)*.

DEER CARRYING CAPACITY OF FORESTED AREAS

The deer problem in Pennsylvania is only part of a much greater and nation-wide problem of game management in relation to forested areas *(12)*. As baffling as was the original problem of conserving and building up the big game supply in the forests of Pennsylvania, is the present question of what to do with the deer herds, which in many places are now greatly in excess of the food supplies available to carry them from year to year. Briefly the problem has resolved itself to this: What is the maximum number of deer that can be maintained on a forested area without detriment to trees or to the deer herd, and without jeopardizing forestry practice or hunting conditions?

Concerning the area of forest land capable of supporting a deer herd there is wide variance of opinion. In some sections of France forest officers attempt to maintain a herd not to exceed ten roe deer on one of their smallest administrative units of about 250 acres. In other parts of Europe attempts have been made to limit the deer population to one deer for each forty to fifty acres. Early German

FIGURE 14. *Planted Scotch Pine Cropped by Deer. When Trees Attain This Size the Damage Done by Deer Does not Ordinarily Kill the Trees, Impede Their Growth, or Seriously Injure Them.*

foresters considered 8 to 16 adult red deer, not counting young, should be the limit for 2,500 acres. In Bohemia 15 to 35 head of red deer could be supported by 2,500 acres, but any addition would result in overstocking. European experience considered one red deer the equal of two fallow deer or four roe deer *(6)*.

Dr. C. A. Schenk *(15)* advocated limiting the number of deer in the Southern Appalachian forests to 150 Virginia deer to 10,000 acres, or one deer to each 66 acres. Another writer states that in Northern Michigan 750 acres are capable of supporting 100 deer in good condition the year round *(1)*. It is doubtful whether a ratio as low as this, one deer to seven and one-half acres, should ever be established under management in Pennsylvania.

The writer, who has interviewed many people familiar with Pennsylvania deer habits, has found that usually opinions as to the deer carrying capacity of forests have been based more on guess than on study. Various estimates received have been to the effect that a single deer requires anywhere from four to fifty acres. Whereas in European practice it may require forty to fifty acres to support one deer, the writer believes that in Pennsylvania considerable less land acreage is required.

When contrasting Pennsylvania with European conditions, we must remember that forestry practices on the Continent date back three hundred years. It is characteristic of many European forests to have an even aged growth and a more or less clean forest floor with very little undergrowth. Accordingly the quantity of browse available to deer is considerably less than in the more brushy, younger, and uneven aged forests of Pennsylvania, where a dense undergrowth normally obtains. In much of our uneven aged hardwood forests, especially in the oak-chestnut type and the beech-birch-maple type, it would appear that adequate food supplies are available to support a herd of deer averaging one deer to as low as fifteen to twenty-five acres. This statement is made bearing in mind that deer will eat vines, herbaceous low plants, weeds, fruit, moss, and roots, which are ordinarily present in the forests of Pennsylvania. But when a figure as low as fifteen or twenty-five acres per deer is considered sufficient then there is more than likely to occur a scarcity of food available to smaller game animals and birds, in as much as these will also largely feed on a similar though perhaps more limited diet. When deer begin to subsist largely on the seeds and twigs of wintergreen, sumac, burdock, forest grasses, and weeds, it is apparent that the region will have a scarcity of such food available to other kind of small game and birds.

A major contributing factor to the support of the greatly increased deer population in Pennyslvania is the abundance of mountain laurel throughout most of the State. It is well-known that though mountain

FIGURE 15. *The Deer Herd Suffers from Overpopulation. A Young Deer Which Died Probably as A Result of Malnutrition or Starvation. Note the Complete Absence of Green Leaves on the Surrounding Vegetation.*

laurel and rhododendron are eaten extensively by deer in times of food shortage, they prefer other species of shrub growth. Nevertheless, during the winter months, mountain laurel becomes the staple diet and therefore this plant, scattered so widely throughout the forests of Pennsylvania, has permitted large numbers of deer to endure the periods of food shortage. Persistent browsing on both the laurel and rhododendron has resulted in the complete disappearance of these species over large areas.

Another observation of considerable interest, as it affects the management of forest stands in relation to game management, is that of all of the major forest types of Pennsylvania, which includes the oak-chestnut type, the aspen-fire cherry type, the white pine-hemlock

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type, the spruce-fir type, the scrub oak type, and the beech-birch-maple type, the last mentioned is apparently either the one providing the greatest bulk of food per acre or the one which ordinarily shows the least damage per acre by browsing deer. This statement is made with the full realization that perhaps the reason why less damage is found in the beech-birch-maple forest type is because deer are not as plentiful in the counties where this is the principal forest type. It is the opinion of many foresters that the beech-birch-maple type, by reason of the dense stands normally found therein and consequently a greater quantity of buds, leaves, and other food materials, is naturally the best adapted in Pennsylvania for supporting the largest deer population. This condition may not have been true twenty-five years ago when the chestnut tree made up a large portion of the present oak-chestnut type, for the chestnut was a species much used as a food by deer.

THE DEER POPULATION IN PENNSYLVANIA

Granted that any method of estimating the deer population must be based on variables, and that definite statistics are lacking, it is nevertheless of value to the scope of this report to attempt to make some estimate of the number of deer in Pennsylvania.

During the buck season of 1930, December 1 to 15 inclusive, according to the Board of Game Commissioners, 20,115 legal antlered deer were shot. If one out of every five bucks was killed, there would remain a buck population of approximately 80,000. Estimates made by game officials, sportsmen, foresters, and others place the proportion of bucks to does in Pennsylvania as one to ten *(5)*. On this basis the present deer herd in Pennsylvania numbers approximately 800,000.

There are in Pennsylvania, according to the latest information gathered by the Pennsylvania Department of Forests and Waters, approximately 13,000,000 acres of forest land. Of this land, more than four million acres are in farm woodlots, or 31 per cent. Many of the small woodlots, in strictly agricultural sections remote from mountain lands, do not support deer. Moreover, there are many tracts of forest lands, not classed as woodlots, on which deer are extremely scarce or absent. As a generalization, therefore, it may be concluded that of the thirteen million acres, constituting the total forest area in the State, only ten million acres support deer. If this estimate be granted, then we come to the rather startling observation that on an average there is one deer to every 12.5 acres of deer-supporting forest.

The deer carrying capacity of Pennsylvania forest, as pointed out in the previous chapter, is estimated to range from as high as 50 deer to 1,000 acres to as low as 25 deer to 1,000 acres, or one deer to forty

acres. The writer believes the deer-carrying capacity of Pennsylvania forests in their present general condition is higher than this latter figure, but in the absence of a more difinite one, and in order to be conservative, it may be accepted for the purpose of this estimate. With an average carrying capacity of 25 deer to each 1,000 acres on the ten million acres of deer-range, we find that the forests of Pennsylvania should have a deer population not to exceed approximately 250,000.

On the basis of these estimates, the deer population in Pennsylvania is more than three times as high as it should be for the best interests of the forests as well as of the deer herd.

FOREST MANAGEMENT AND GAME MANAGEMENT

Forestry practice consists in putting timber growing land to its highest possible use. This does not imply the exclusions of all except those factors directly leading to maximum timber production. Although raising timber is the major function of forestry, there are at least three other phases of forest management, especially as they apply to public lands, that are of prime importance: economic use of waste lands, conservation of water supplies, and provision for the recreational needs of the public.

Game management, the art of controlling land and animals so that an optimum game population may exist *(10)*, is an important consideration in forest recreation. One of the bases upon which the State Forests of Pennsylvania were created was to provide outdoor recreation to all citizens of the Commonwealth, and for this reason the foresters of Pennsylvania have always been among the most ardent advocates of game conservation and management. When game, as for example, deer, increases to the point where fundamental forestry practice and the highest use of forest land is jeopardized, the problem becomes one of balancing the two in order to permit them to be mutually beneficial and not antagonistic *(11)*.

The foresters of the Pennsylvania Department of Forests and Waters are greatly interested in maintaining an optimum game population just as they are interested in growing and protecting crops of timber. Because they are scientifically trained and since their work takes them into the woods, foresters are generally well acquainted with game conditions. It is the consensus of opinion of many Pennsylvania foresters that a certain amount of forest growth may well be sacrificed in order that a large deer population may be maintained, perhaps even above what would be considered by those experienced in scientific game management to be the optimum population. On the other hand, they realize fully that when the deer herd increases to the point where not only the forest growth becomes severely deteriorated, but becomes

insufficient to supply the deer herd with food, then in the best interests of the deer population as well as of the forests a more natural balance must be attained.

Three adverse situations, caused by over-population of deer, are now common in many sections of Pennsylvania. First, the forest growth, and consequently forestry practice, suffers. Second, the deer herd by consuming practically all the available food supply and ruining the forest cover causes a sharp decrease in the number of wild turkey, grouse, pheasant, quail, rabbits, squirrels and other small game. Third, the deer, because they cannot find an adequate supply of food, are undernourished, a condition permitting easier infection by diseases such as pneumonia and rickets, and the breeding of parasites, with a resultant deterioration in bodily vigor and size. This type of deer is not what game conservation and scientific game management are designed to produce.

"Variety in game is quite as valuable as quantity." It is not fair or wise to adopt any practice of game management which provides sport for one class of hunter and denies it to another. But this in effect is what follows an abnormally high deer population. Game, all kinds of woodland game, should become a major Pennsylvania forest product.

Today in Pennsylvania we are faced with the problem of the disposal of surplus animals in forested areas no longer able to supply adequate food. The State Forests of Pennsylvania are administered on a permanent basis just as the control and management of game by the Commonwealth is on a permanent basis. It would be decidedly unfair to the recreational rights of Pennsylvania citizens for any system of forest management to be followed that would permit anything short of the optimum production of game. At the same time it would be a short sighted policy to encourage the production of game beyond the carrying capacity of the forest. It is believed that some natural balance may be struck and maintained.

REFORESTATION WITH DEER PROOF FENCES

The destruction by deer of numerous forest tree plantations, ranging in size from 1,000 trees to nearly 200,000 trees each, indicated that the situation was so serious as to warrant the discontinuance of reforestation on large areas pending the discovery and application of practical control measures.

Certain experimental planting activities, however, were carried out during 1929 and 1930, though it was necessary to enclose these within deer proof fences. For example, under a cooperative project between the Pennsylvania Department of Forests and Waters and the U. S. Department of Agriculture, Bureau of Plant Industry, Chinese chestnut seedlings were furnished by the latter department for planting in

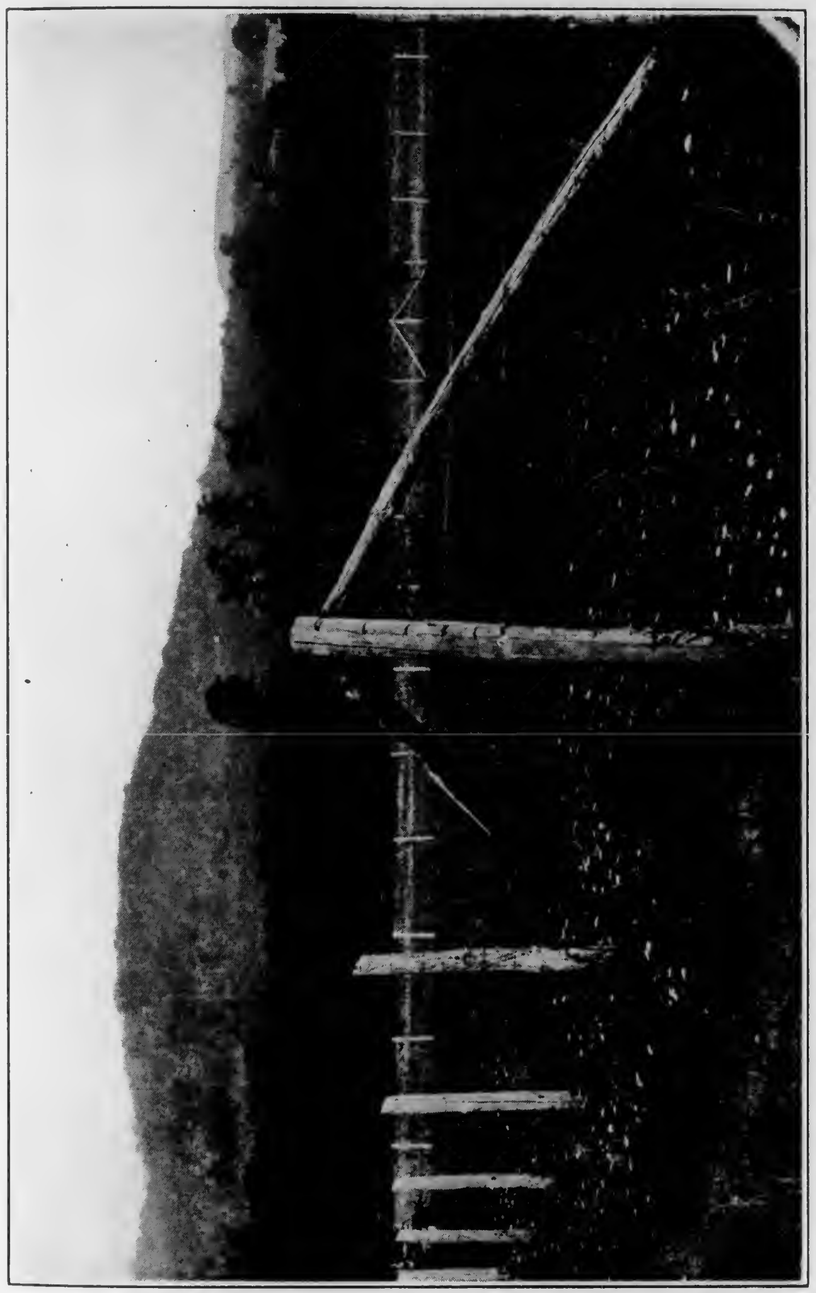

FIGURE 16. *An Effective but Expensive Method of Protecting Trees from Deer. A Deer Proof Fence, Seven and One-half Feet High, Enclosing A Forest Tree Plantation. Pine Grove Furnace, Cooke Township, Cumberland County.*

insufficient to supply the deer herd with food, then in the best interests of the deer population as well as of the forests a more natural balance must be attained.

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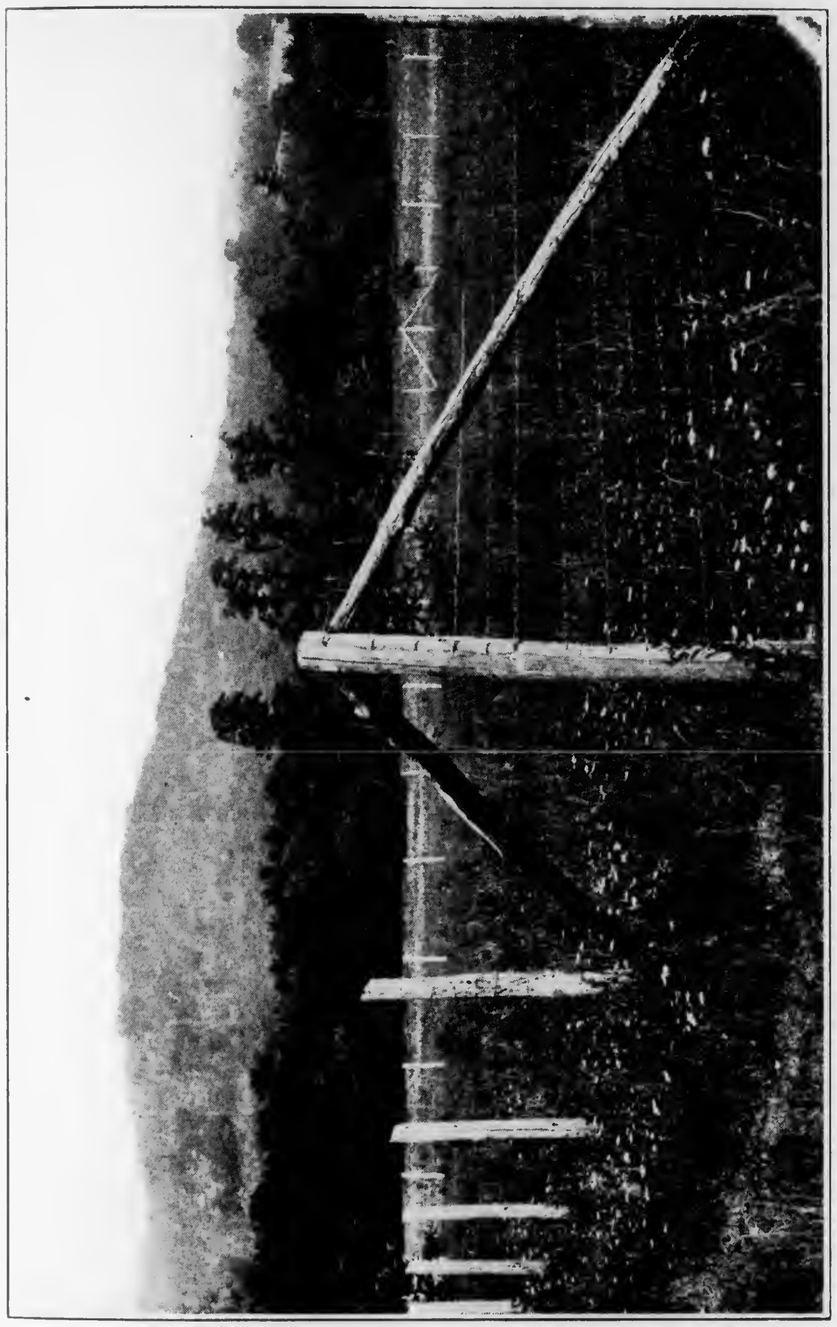

FIGURE 16. *An Effective but Expensive Method of Protecting Trees from Deer. A Deer Proof Fence, Seven and One-half Feet High, Enclosing A Forest Tree Plantation on Pine Grove Furnace, Cooke Township, Cumberland County.*

INTENTIONAL SECOND EXPOSURE

State Forests to determine the suitability of the Chinese chestnut as a possible substitute for our native chestnuts, which had succumbed to the chestnut blight.

Three large reforestation projects, partially within deer proof fences, were made in 1929 and 1930 in Elk, Cameron, and Clinton Counties, in State Forests.

Cameron County. The Red Run plantation, along the Lincoln Road, in Gibson Township was established in 1930. Fourteen acres were inclosed within deer proof fence and planted with trees. In addition, seven acres outside the fence were planted. The principal species were Scotch pine, red pine, Norway spruce, and Japanese larch, with some white ash and red oak. One thousand Chinese chestnut seedlings were also planted inside the fenced area. Both inside and outside the fence, the small aspens, fire cherry, and berry bushes were mowed to facilitate the planting.

When examined in September, 1930, the Norway spruce, red pine, and Scotch pine had an establishment of approximately 88 per cent, despite the severe drought of the summer of 1930. The larch, however, had only approximately 15 per cent living. These percentages applied to the trees both inside and outside the fenced area. Very little deer damage was noted on the trees outside the fence, though some were nipped. This was to be expected since the greatest damage to planted trees is ordinarly done over the winter months; these trees had been growing in the plantation only since spring. There was evidence in abundance of considerable damage to the natural growth outside the fence, indicating that deer are present in sufficient quantities to cause great losses.

Elk County. The Snook's camp plantation was established in the Spring of 1930 along the McDonald branch of Dent's Run in Benezette Township. Forty acres were enclosed within deer proof fence of which 32 acres were planted in the Spring of 1930, with red pine, Scotch pine, Norway spruce, Japanese larch, and a small number of hardwood seedlings.

When examined in September, 1930, the trees in the fenced area were growing well despite the severe drought of the past summer. The red pine and Scotch pine had an establishment of approximately 90 per cent, and the Norway spruce, which apparently resisted the drought poorly, had an establishment of approximately 63 per cent.

A plantation was established outside, and adjoining, this fenced area in 1929. Notwithstanding the fact that these planted trees were very small, averaging 5-7 inches in height, and were therefore easily covered with snow and difficult for the deer to find, the deer damage during the first overwintering season was high. Damage attributable to deer

FIGURE 17. *A Deer Killed as A Result of Running into A Deer Proof Fence.*

to the various species, when examined in September, 1930, was as follows: Scotch pine, 22 per cent; Norway spruce, 20 per cent; and red pine, 38 per cent. European larch had apparently been severely damaged by deer and only a few living trees of this species could be found.

Clinton County. A plantation was established near the Homewood Club along Cooks Run in East Keating Township in the spring of 1928, on an area which had been burned severely following lumbering operations. Of a total of 150,000 pitch pine, white pine, red pine, and Norway spruce trees, scarcely one survives today. The planting stock was small and many died from natural causes, but most were eaten by deer.

A deer proof fence, enclosing five acres, was erected and the site was planted in the spring of 1930 with red pine, Japanese larch, Scotch pine, Norway spruce, and a small number of hardwood seedlings. In addition Norway spruce and Scotch pine were planted outside the fenced area, but these species showed little deer damage, when examined in September, 1930, inasmuch as they had not been exposed to the deer during an overwintering season.

The young natural forest reproduction on this site had been almost destroyed by deer, which in this section are numerous and consequently very destructive.

Clearfield County. Plans have been made to fence and plant another tract of about 40 acres within the region of extensive deer damage in

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INTENTIONAL SECOND EXPOSURE

Clearfield County in the Spring of 1931. Reforestation activities are costly at best, but when to the costs of seedlings and planting must be added the costs for expensive deer proof fences, reforestation becomes a forestry activity the extreme need for which is its only justification.

CONSTRUCTION AND COST OF DEER PROOF FENCES

Deer proof fence, usually seven and one-half feet high, is erected by stretching commercially manufactured fence, made of number 9 galvanized iron wire, on posts having a top diameter of six to twelve inches. The construction must be sufficiently strong to withstand fire, deer running into it, hunters climbing over it, and frost heaving of the ground. The posts may be set about one rod (16½ feet) apart, and should be of a species of wood which is fairly strong and durable, such as chestnut.

The cost of erection varies according to the labor rate, the distance the men and material must be transported, and the condition of the site, whether brushy, rocky, steep, or swampy. In Pennsylvania the expense of construction varies considerably; in favorable locations it may be as low as $2.50 per rod. In adverse sites the cost may be as high as $5.60 per rod. The average is approximately $4.00 per rod. These figures include fence, posts, guy wire, staples, and labor.

Since the circumference of a circle having the same area as a square is less than the perimeter of the square, the cost of fencing circular areas is always less than the cost of fencing squares. By taking advantage of this mathematical law, foresters engaged in constructing deer proof fences may save considerable money both for materials and labor.

For example, to fence a tract of ten acres in the form of a square requires approximately 160 rods of fence, but to enclose the same area in the form of a circle requires only 141 rods of fence. If the cost of construction averages $4.00 per rod, the saving effected amounts to $76.00.

Examination of the foregoing table indicates how the average cost per acre of constructing fence decreases as the area to be enclosed increases. For example, at $4.00 per rod the average cost per acre to fence one acre in the form of a square is $204.00; to fence two acres costs $144.00; five acres, $90.40; ten acres, $64.00; and for 50 acres the average cost per acre is only $28.64.

To determine the number of rods of fence required to enclose an area in the form of a square, the following formula may be used having first reduced the acreage to square feet:

$$\frac{\sqrt{\text{area} \times 4}}{16.5} = \text{perimeter in rods}$$

TABLE 6. ESTIMATED COSTS AND NUMBER OF RODS FENCE REQUIRED TO ENCLOSE SQUARE AND CIRCULAR AREAS

Size of Area (Acres)	Square Areas				Circular Areas			
	Approximate Perimeter (Rods)	Approximate Total Cost If Cost Per Rod Is			Approximate Circumference (Rods)	Approximate Total Cost If Cost Per Rod Is		
		$2.50	$4.00	$5.50		$2.50	$4.00	$5.50
1	51	$127.50	$204.00	$280.50	45	$112.50	$180.00	$247.50
2	72	180.00	288.00	396.00	64	160.00	256.00	352.00
5	113	282.50	452.00	621.50	100	250.00	400.00	550.00
10	160	400.00	640.00	880.00	141	352.50	564.00	775.50
20	226	565.00	904.00	1243.00	200	500.00	800.00	1100.00
25	253	632.50	1012.00	1391.50	224	560.00	896.00	1232.00
50	358	895.00	1432.00	1969.00	317	792.50	1268.00	1743.50
100	506	1265.00	2024.00	2783.00	448	1120.00	1792.00	2464.00

To determine the number of rods of fence required to enclose an area in the form of a circle, the following formula may be used, having first reduced the acreage to square feet:

$$\frac{(\sqrt{\text{area}} \times 1.128) \times 3.1416}{16.5} = \text{circumference in rods}$$

The foregoing formula is based on the fact that the side of a square times 1.128 equals the diameter of an equal circle. The diameter of a circle times 3.1416 equals its circumference. Dividing the result by 16.5 gives the circumference in rods.

REFORESTATION WITHOUT THE USE OF DEER PROOF FENCES

Pennsylvania foresters confronted with reforestation problems in regions of high deer population have the choice of three systems of protection, all of which are costly.

(1) The erection of deer proof fences within which to conduct reforestation projects is justified principally for experimental purposes or for regions where, without tree planting, the land will suffer extreme deterioration.

(2) Deer repellents may be applied to young trees. Developed in European forestry practice, this form of treatment consists of sprinkling, daubing, or smearing the branches with mixtures of various obnoxious substances, including tar, blood, dung, grease, tallow, alum, lime, sulphur, and refuse hemp. The usual procedure is to make the applications after the trees have been planted. Depending upon the size of the plants and the condition of the ground, whether sloping, rocky, or brushy, a worker can treat from 500 to 3,000 trees per day. Some species, such as spruce, withstand the treatment less well than others, such as Scotch pine. Broad-leaved species suffer from the use of tar, and care must be taken to avoid smearing the buds of conifers with coal-tar *(18)*.

This practice has had but little application in America, except experimentally. Information as to the efficiency of deer repellents in American forestry practice is meager, and the number of applications necessary to protect seedlings until they attain a height beyond the reach of deer is not known. Likewise the costs of such operations, obviously higher than in Europe where a low labor wage prevails, are not available. This practice in the protection of forests from deer deserves some research effort, if only to determine whether or not it is practicable and economically justified.

(3) Another deer damage preventive measure consists in shielding the trees with loppings. This system has been successful in certain

reforestation projects in Pennsylvania where the planting sites supported a growth of hardwoods of poor quality. It is especially applicable in the conversion of scrub oak.

The procedure is simple enough; the planted trees are set out, either in rows or by the spot planting method, and then covered with lopped brush. Deer are apparently disinclined to force their heads into these brush piles to eat the planted trees. It is understood that this method of planting is not advocated for open areas, but only where some form of inter-planting is contemplated. It is further restricted to planting where the native hardwood species are to be converted or reinforced. When cleanings are necessary, the lopped brush can be used to protect the planted trees further.

The lopped species, when piled high, dry out and become stiff and resist penetration by deer. The wood rots slowly, protecting the planted trees for several years, during which time their growth is practically unimpeded by the comparatively light shade of the loppings. This method is now in use in a scrub oak conversion project on Kettle Spring Mountain in the Mont Alto State Forest in Franklin County, and on the Lackawanna State Forest in Lackawanna County, where plantings have been made under gray birch, fire cherry, and other so-called weed species.

If in Pennsylvania there were any forest trees repellent to deer or any that deer rejected as food, the solution of the reforestation problem would be comparatively simple. The author knows of no forest trees in Pennsylvania that are immune or resistant to deer damage, although Norway spruce and white spruce have occasionally been observed to suffer less cropping than other species.

SUGGESTIONS FOR IMPROVING THE DEER SITUATION IN PENNSYLVANIA FORESTS

The Deer Range. Careful and unbiased studies conducted by the Pennsylvania Department of Forests and Waters, the Pennsylvania Board of Game Commissioners, the United States Biological Survey, and other agencies have shown that extensive forested tracts are greatly overstocked with deer. Food supplies in these areas are dwindling and the forest cover is deteriorating rapidly. Fundamental forestry practice is handicapped, and reforestation activities especially have been abandoned, following the almost complete destruction of hundreds of thousands of planted trees. Under present conditions in many State Forests timber cutting operations cannot be carried on except in the form of thinnings, because the deer consume the natural reproduction that is depended upon to produce a future timber crop.

A calculated reduction of the deer herd is suggested in those forested sections of Pennsylvania where the greatest damage is being done to

tree growth (See frontispiece map). This reduction should be based on the carrying capacity of the forest, and it would be beneficial if the reduction were slightly under the carrying capacity. These woodlands are at present practically denuded of food supplies necessary to carry the deer on a year-round basis, therefore their carrying capacity should be less until the forest grows back to normal conditions, which may require five or ten years *(3)*.

The Deer Herd. The plan, in vogue in Pennsylvania until the past few years, of legalizing the killing of bucks only has resulted in a disproportionately large doe population. Because they have been unmolested the does have apparently lost much of their natural timidity. The huge excess of does over bucks has resulted in a poorer quality of offspring, and biologically the herd is deteriorating. In the course of nature only the largest and strongest males serve the does *(16)*, but under present conditions, however, sexually immature males become parents of fawns that are physically inferior. In addition, promiscuous breeding has resulted in young being born late in the summer, and these are often not sufficiently developed to compete successfully for food with stronger deer. Consequently they lose out in the struggle for existence during the food shortage periods in the severe winter months.

Nature is wasteful and all animals in a state of nature tend toward overproduction. The Pennsylvania deer herd, protected by law and almost wholly safe from predatory animals, is the victim of an unnatural situation in which it is being literally reproduced to the point of biological inferiority. Biologists, vetenarians, and laymen who have studied this phase of the situation are agreed that the proper course of action to build up the deer herd physically would be to effect a marked decrease in the number of doe deer compatible with the male deer population.

A more healthy balance between the sexes would appear to be in the proportion of one buck to five does. Some biologists have suggested lowering the proportion to one male to three females. It has been estimated that with one half the present female population and twice the present male population the fawns produced would be twice the present number *(2)*.

Special Open Seasons. It is not within the scope of this study to suggest the manner in which the reduction in the deer herd is to be brought about for that is an administrative function of the Board of Game Commissioners. A plan of game management may be determined that will permit the balancing of the deer herd in regions where damage to the forest and other crops is exeessive. This plan may be based on the present site of the herd in relation to the carrying

capacity of the forest, and the reduction, which is almost without exception required in the female herd only, may be brought about by special open doe seasons.

Better Distribution of Deer. Deer apparently have a tendency to concentrate in large herds in limited areas where starvation frequently follows the exhaustion of food supplies. This phase of the problem invites research; a practical method of scattering the deer or of driving them to new feeding grounds would be of great assistance in the management of the game as well as the forest. Trapping deer in overstocked regions and transporting them to thinly populated sections cannot be offered as a solution owing to the difficulty and huge costs involved. Notwithstanding the fact that most of the deer range in Pennsylvania is now either greatly overstocked or approaching that point, there remain thousands of acres, especially in the northern tier counties, where, if the surplus from other sections could be distributed an abundance of food would be available.

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